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ABSTRACT (Maximum 200 words)

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Underwater Vertical Digital Communication System
Optic Control of Undulating Platforms
Marine Entrepreneurs & Law of the Sea (Soapbox)

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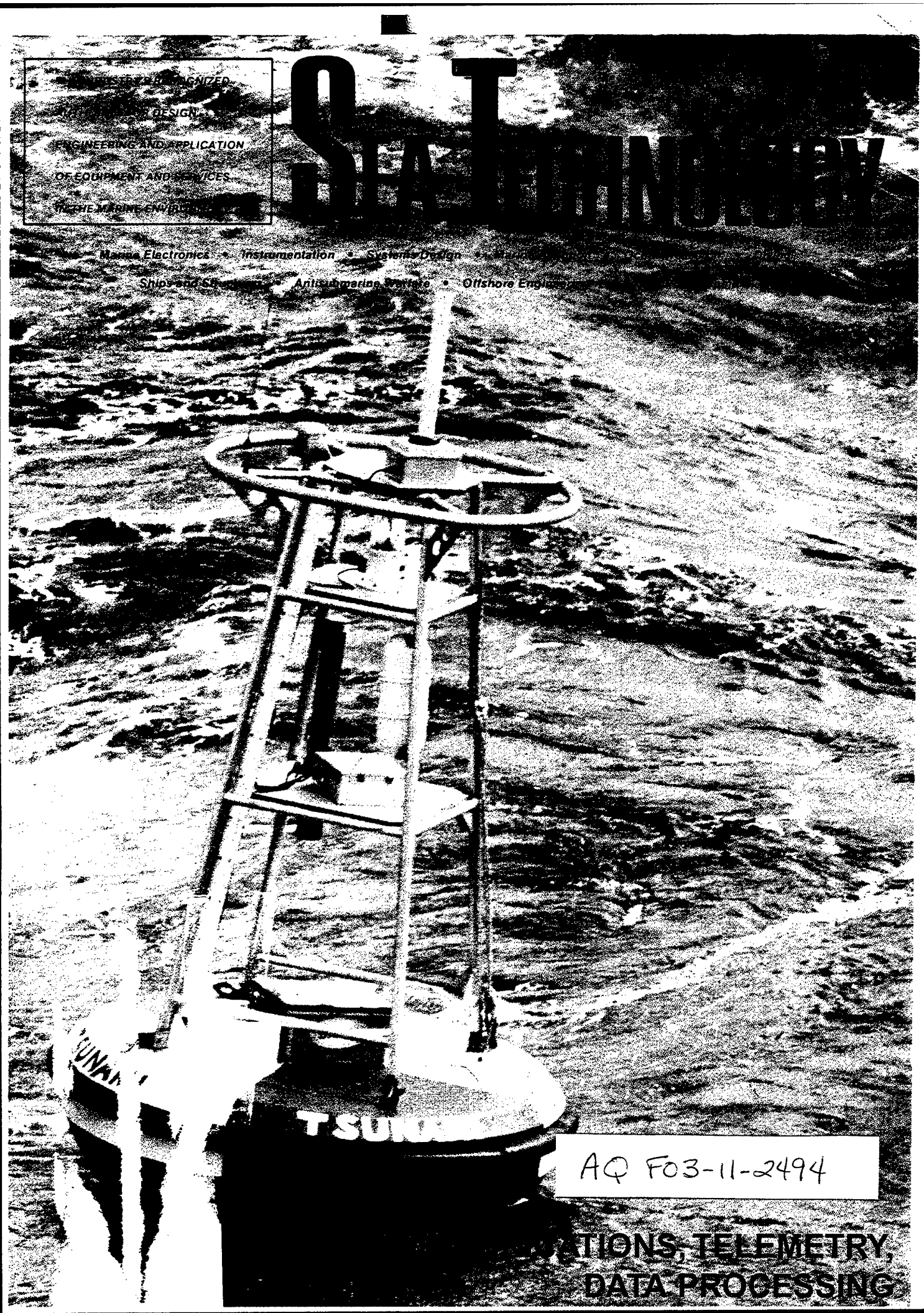
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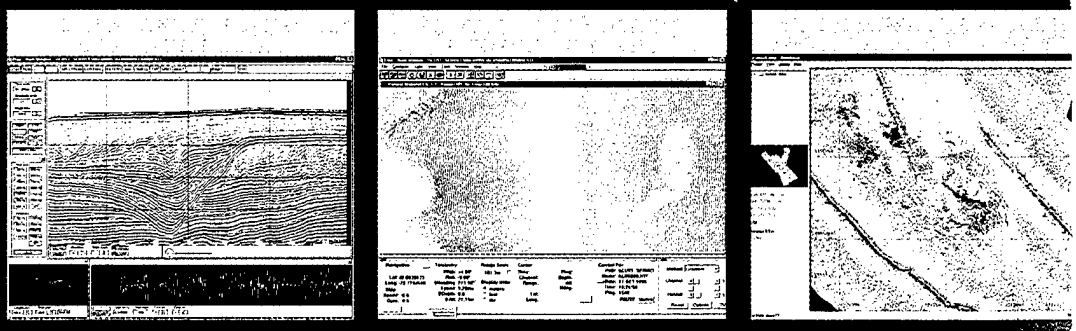

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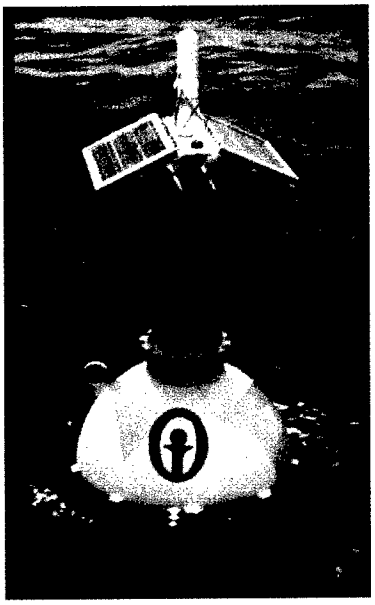

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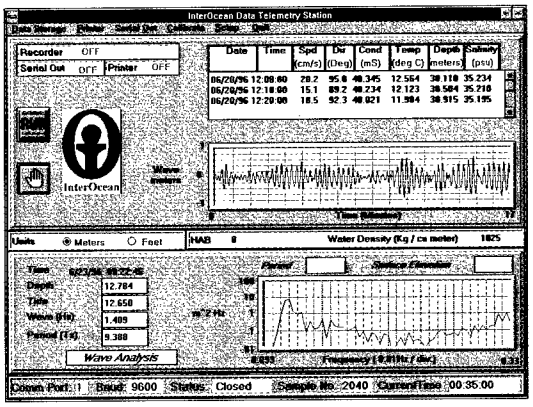

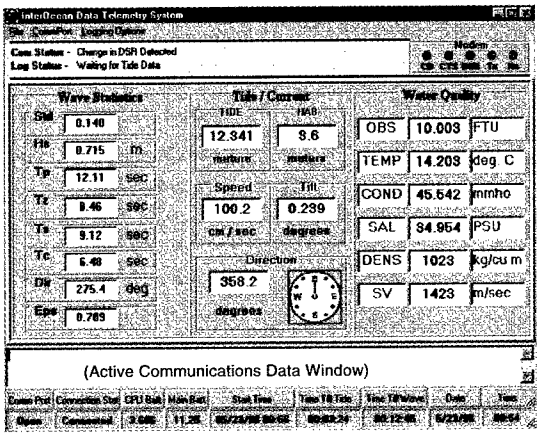

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May 1998, Volume 39, No. 5

Cover—This NOAA buoy deployed in 3,000-meter waters in the north Pacific is part of an ambitious tsunami hazard mitigation program run by the agency's Pacific Marine Environmental Lab in Seattle. Precise pressure measurements made at the seafloor are transmitted via Datasonics Inc. modems to the surface and then transmitted by GOES satellite to PMEL. Data are also sent to NOAA Tsunami Warning Centers in Alaska and Hawaii. When fully operational, six such buoys around the Pacific will provide early warning of impending tsunami. (Photo courtesy of Steve Niland, Datasonics Inc.)

Next Month—ECDIS standards: where are we?...Raster scan update...UNOLS fleet status...Undersea topography classification at NAVO...Long-range mine detection...Tidal overlays for ECDIS...LADS depth sounder improvements...Deep sea earthquake monitoring.

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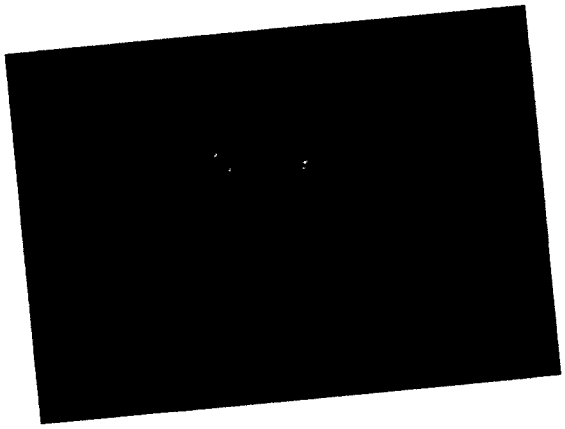

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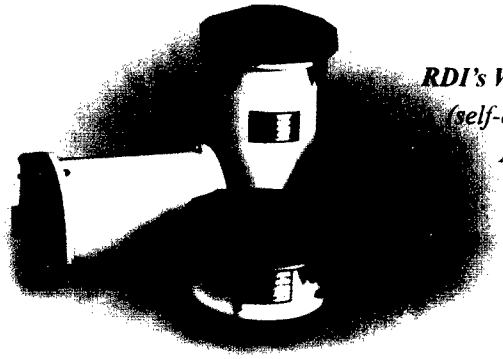

RDI's Workhorse Family *(Clockwise) 300 kHz Sentinel (self-contained) ACDP, 300 kHz Monitor (direct-reading) ADCP , 1200 kHz Monitor ADCP, and external battery case.*

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David M. Graham

Let's Hear It for YOTO!

We are well into the International Year of the Ocean as promulgated by the United Nations and spearheaded domestically by the National Oceanic & Atmospheric Administration. Up to this point, it appeared from the bleachers from time to time that the United States was faltering in this significant opportunity to display world leadership in ocean affairs.

But something is, in fact, happening.

Most recently, one of the most ambitious projects related to the Year of the Ocean appeared in print. It is as we have discovered a compendium containing information about nearly everything that's happening—and some things that are not—in the world's oceans.

Entitled *Year of the Ocean Discussion Papers,* this impressive document is the result of a lot of hard work by NOAA's Dr. Stan Wilson, Charles Bookman of the H. John Heinz III Center for Science, Economics & the Environment, and a host of authors. In the cover letter, NOAA's Dr. Jim Baker notes that this set of papers "addresses a variety of themes and issues—what is working well and what is not working well, needs, and opportunities for the future." The volume is a starting point, he adds, that provides background information to assist private and public sectors to work together to promote conservation, exploration, and sustainable use and national security interests of the ocean.

On the international scene, construction is rampant in Lisbon, Portugal, site of the actual Expo 98 where exhibits and buildings are sprouting. Scheduled for a May 22 opening, the exposition will run until September 30 and is costing approximately $1.7 billion. Organizers expect something like 15 million visitors. And make no mistake about it; the colorful monthly tabloid *Expo 98 News* indicates the exposition is decidedly oceanic in nature and form.

The U.S. Pavilion will highlight the overall Expo theme, "The Oceans—A Heritage for the Future." Major exhibitors within the U.S. Pavilion will be the U.S. Navy, the National Institute of Environmental Health Sciences, NOAA, and numerous ocean-related education and science institutions. All are expected to display cutting-edge U.S. ocean technologies and research efforts. Many of the actual exhibits will be interactive and user-friendly.

The current efforts bring to mind another YOTO—a decade-plus ago but with similar ambitious goals. This magazine proudly played a major role in the conception and leading of that 1984-85 "Year of the Ocean." Its goals also were to "expand public awareness and knowledge of the importance of the oceans and its resources, promote a sense of stewardship among ocean organizations and industries for the ocean and its resources, and foster a public/private partnership for the wise use and management of ocean resources." We've heard a lot of the ideas repeated since. It was successful and many residual benefits of the effort are still in play today.

Back to the *Discussion Papers.* One observer of the ocean scene noted that the volume seemed to contain very nearly everything one would want to know about what's going on today.

Fully an inch thick, the volume reports the U.S. transportation system will be part of an international trade where more than 90 percent (by weight) of all goods will move via the oceans. Regarding oceans and national security, writers noted that the United States owes much of its security and prosperity to the ability to use the seas successfully. Key to this success is preservation of the legal regime set forth in the Law of the Sea Convention. Ocean living resources, the volume states, provide immense benefits. Human activities are threatening those resources and their benefits, however, and continued better management and conservation practices can pay dividends in healthier resources.

In one of the more telling statements, the section on Marine Science, Technology, and Research states: "From such prestigious scientific bodies as the National Academy of Sciences and its many associated boards, from well supported needs statements of the mission-oriented federal agencies, and from a variety of highly respected scientific organizations, the question of 'what to research' in areas of ocean science and technology is outlined quite well. The International Year of the Ocean provides opportunities to highlight ways that new and enlightened partnerships can be established to provide the bonding agents needed to pull the currently disparate parts of the nation's oceanographic enterprise together."

Well said. It would behoove the entire ocean community to embrace that paragraph as a goal. All it takes is cooperation. */st/*

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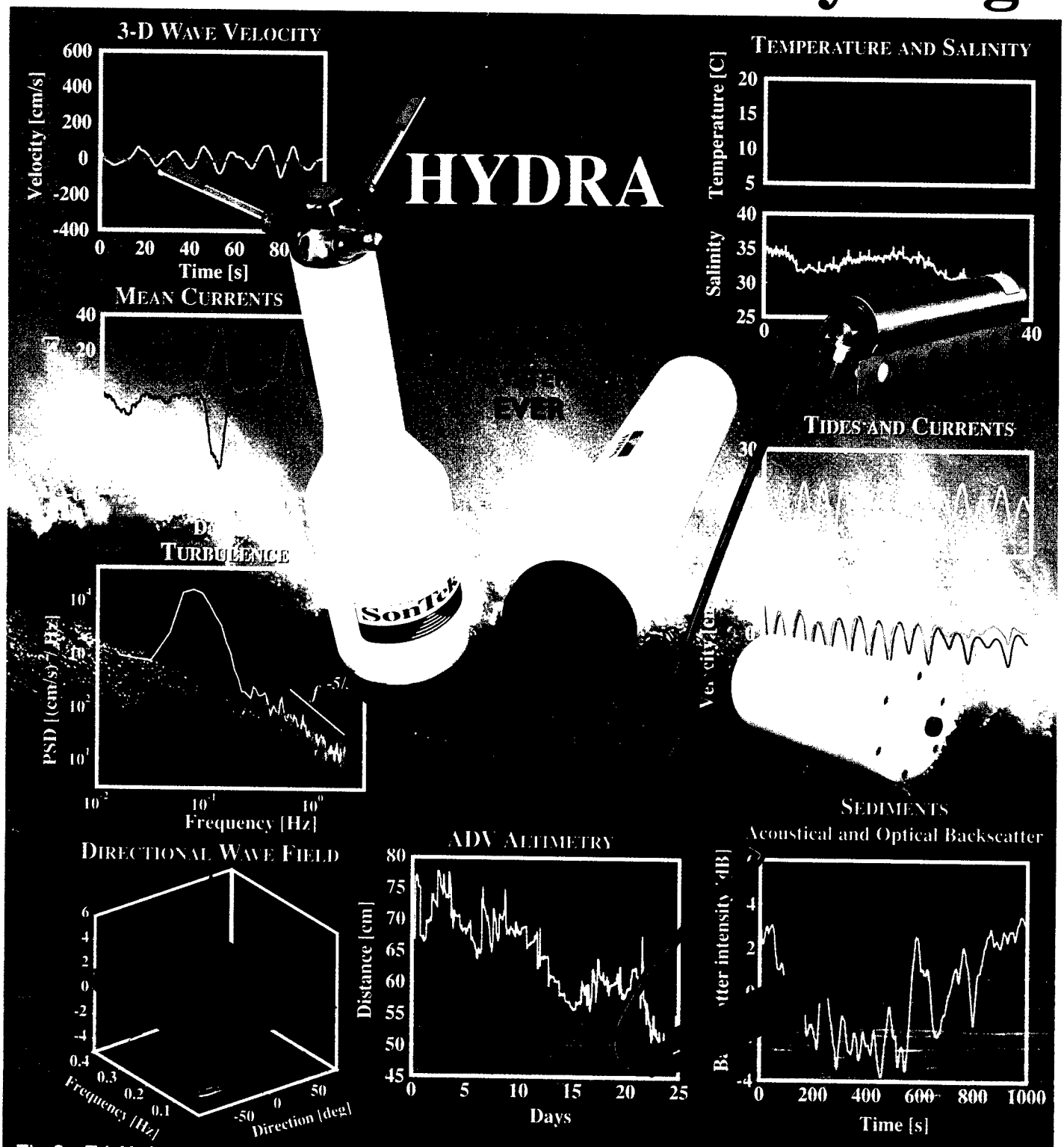

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))) **Kasich Would Cut $154 Billion, Eliminate Commerce, Energy in New Budget.** Rep. John R. Kasich (R-Ohio) is said to be nearing completion of a new budget plan that would cut domestic funding by an additional $154 billion over the next five years to underwrite new tax cuts, increase highway spending, and add other congressional interests. He chairs the House Budget Committee, which has been stymied for some months by indecision over spending and tax priorities. In his "where have I heard this one before" announcement, Kasich again calls for the elimination of the departments of Energy and Commerce, a reprise of proposals by Freshmen Republicans that were rejected during the 1995-96 budget conflict between Congress and the Clinton administration. Kasich and other senior panel members say the plan—still in the works—attempts to reconcile competing interests while advancing Republican philosophy. But the proposal seeks far more in tax relief and spending cuts than allowed under the Senate's budget resolution and has drawn fire from some who fear the cuts are too draconian and politically unacceptable. House Appropriations Committee chairman Bob Livingston (R-Louisiana) noted the appropriations bills for the coming fiscal year already are tight and he expressed doubted he could win majority support for more cuts. Kasich has also come under attack from members of his own party who claim he is putting presidential ambitions ahead of congressional responsibilities by presenting a budget plan that appeals to the GOP conservative base but can't be passed.

))) **Massachusetts Team Rolls Through National Ocean Science Bowl Finals.** A team of science students from Lexington, Massachusetts, took top honors in the 1998 National Ocean Sciences Bowl last week in Washington. The five boys and coach Scott Carpenter from Lexington High School "blew away the competition" and went undefeated to win an all-expense-paid learning trip to Portugal. The team took first place in the national competition that ended April 28 in Washington, D.C., prevailing over 15 other high school teams. The competitors answered rapid-fire questions on biology, chemistry, geology, physics, history; economics of the ocean; and ocean-related current events developed by top researchers and educators in the marine sciences. Team members—Rafael Bras, Rudolf Faust, Yuen-Jong Liu, Andrew Lin and Perry Dougherty—are coached by Scott Carpenter. They will be invited to travel this summer to Lisbon, Portugal, during Expo 98, which celebrates the International Year of the Ocean. The second and third place teams were Woodward Academy of College Park, Georgia, and North Marion High School of Aurora, Oregon. This is the first year of NOSB, being held appropriately in the International Year Of The Ocean, noted Adm. James D. Watkins, president of the Consortium for Oceanographic Research & Education (CORE). The organization, in partnership with the National Marine Educators Association (NMEA), conducted the bowl. Sixteen regional meets, involving about 200 teams, were conducted by CORE institutions around the nation. NOSB finals were held on the Campus of Gallaudet University in Washington, D.C., April 26-27. Goal of the competition was to recognize and reward excellence among students interested in ocean studies and to help them become the next generation of oceanographers and marine scientists. The bowl was intended to broaden awareness of the critical value of ocean research among high school students, educators, parents, and the public. Private support for the National Ocean Sciences Bowl was provided by Capital Assets Inc., Compass Publications, Edison International, Oceaneering International Inc., Sippican Inc., Sea-Bird Electronics Inc., Sea Education Association, and Viking Models.

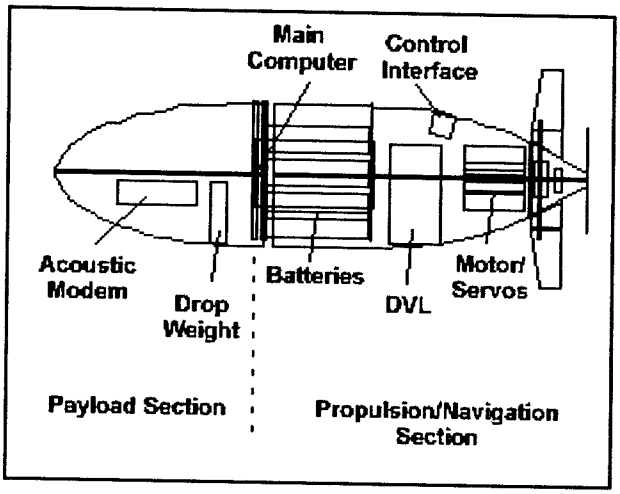
))) **Federal Managers Issue Fisheries Management Guidelines**. Federal officials responsible for managing the nation's marine fish stocks recently issued a series of national guidelines with the purpose of rebuilding overfished fish stocks and reducing the amount of fish inadvertently caught and discarded. The new overfishing and bycatch guidelines were developed by NOAA's National Marine Fisheries Service as the agency interprets new national standards and revises existing standards in response to the 1996 congressional amendments to the Magnuson-Stevens Act. The amendments added provisions to address overfishing and the optimum harvest of marine fisheries, bycatch of unwanted species, effects of fisheries management actions on fish dependent communities, and safety at sea. The national standards are used as guideposts by eight regional fishery management councils and NMFS itself when developing and revising regulations used to manage hundreds of marine fish stocks caught by commercial fishing and recreational anglers around the country. The Sustainable Fisheries Act of 1996 substantially amended the Magnuson-Stevens Fishery Conservation & Management Act, requiring a more conservative approach toward management of the nation's fisheries. While the Magnuson-Stevens Act has always required the prevention of overfishing, Congress has now defined the term, directed the agency to identify overfished stocks, and required the councils and the agency to take specific actions to end overfishing and to rebuild overfished stocks within specific periods of time. */st/*

Peer-to-Peer Communication Protocol

For Deep-, Shallow-Water Communication, Modem Protocol Enables Coordination Among Multiple Platforms—Reliably, Effectively

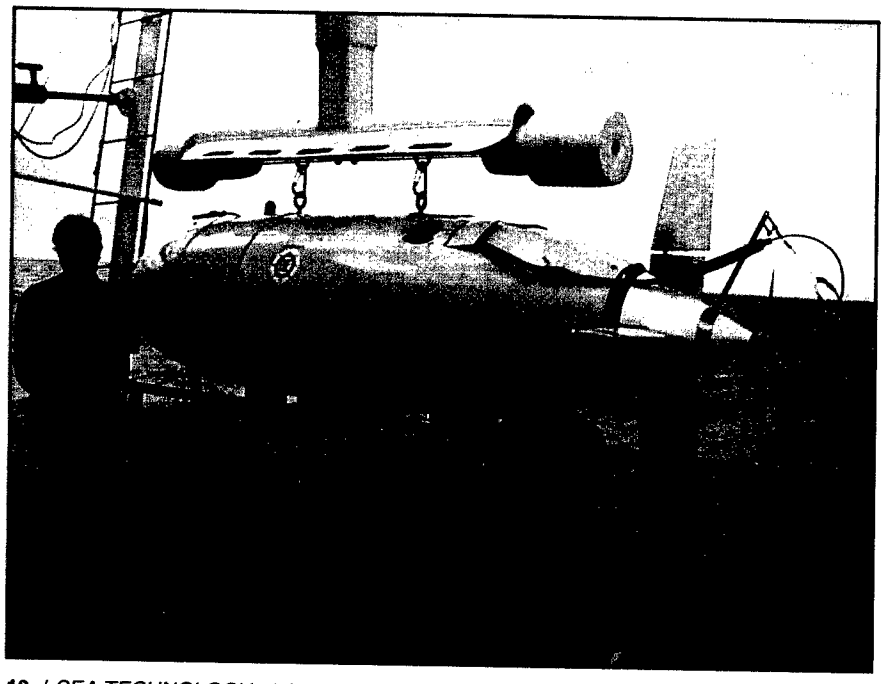
By Alan Neel
Senior Engineer
EdgeTech
Milford, Massachusetts
and
Dr. Lester R. LeBlanc
Dr. Joseph C. Park
Dr. Samuel M. Smith
Department of Ocean Engineering
Florida Atlantic University
Boca Raton, Florida

In a joint research effort with EdgeTech, the Advanced Marine Systems (AMS) group at Florida Atlantic University (FAU) has developed a peer-to-peer communication protocol for use with acoustic communication systems interfaced with Ocean Explorer (OEX) AUVs. The unique architecture of this system allows the communication channel between numerous underwater platforms to remain open, therefore allowing important information to be transmitted at any time. The protocol has been implemented in an acoustic modem that is capable of transmitting binary data through the shallow-water acoustic waveguide. It is not limited to shallow-water work. The protocol is beneficial in meeting the demands of both deep- and shallow-water acoustic communication.

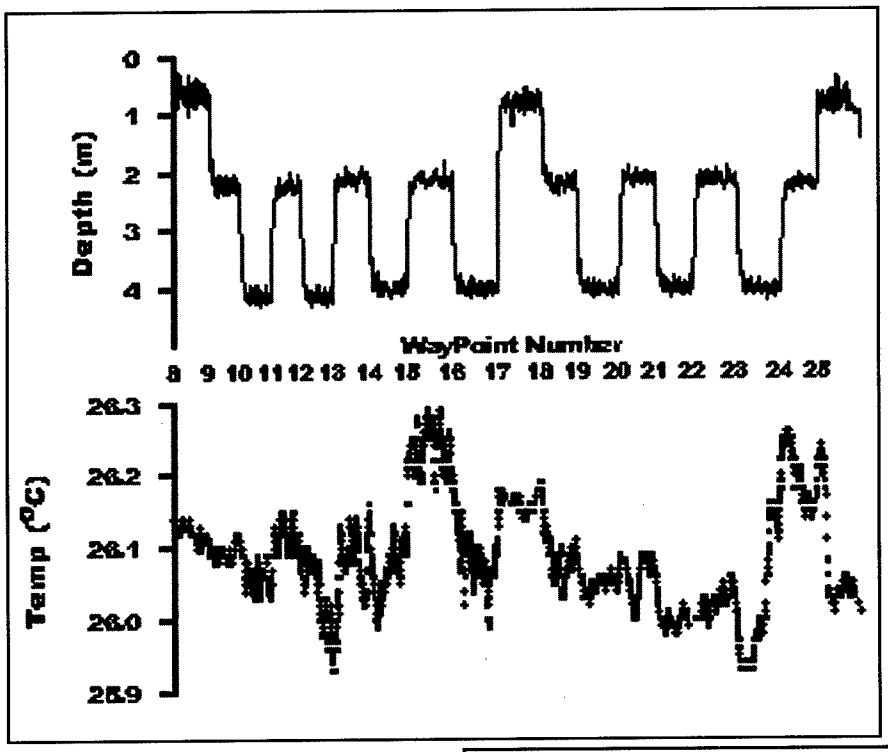


Below is OEX AUV Above are major functional components of the vehicle.

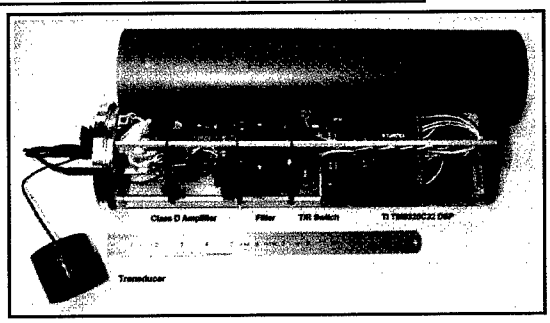
Coordinated action is one requirement of the Autonomous Oceanographic Sampling Network (AOSN) for communication involving multiple underwater sampling platforms: AUVs, moorings, floaters, and support vessels. To accomplish coordinated action, sampling platforms have to communicate through underwater channels and exchange not only telemetry but also command and control messages. The safety of AUVs, as well as all other operating platforms, depends on reliable underwater communications that allows for timely exception reporting by the platform, as well as providing a human override of preplanned missions. These tasks do not necessarily require high-bandwidth communications but rather timely and reliable communications between multiple platforms.



Until now, this requirement has been difficult to fulfill. The traditional communication scenario involves a point-to-point protocol wherein a link is



The layout of the acoustic modem uses custom four layer boards in a 4-inch diameter tube. Graph above shows depth and temperature data recorded by the CTD sensor versus waypoint number, corresponding to OEX's in-water track. Acoustic communications were maintained even with the OEX operating on the surface.



established between two discrete telemetry units, or in some cases a broadcast mode is employed to allow a one-to-many information transfer. These protocols depend on a dedicated channel access between two telemetry units, or in the latter case between a master and many slaves. Such an arrangement prevents arbitrary access to the channel, and may result in disastrous consequences in the event that emergency or high-priority information becomes available without channel access. An effective protocol must also avoid collisions between transmissions from arbitrary telemetry units, which could occur in a completely open channel, and be flexible enough to accommodate any signaling format. Also, traditional communication methods do not operate as effectively under the constraint of long channel delays, which dominate acoustic underwater communications.

The AMS Group's new peer-to-peer communication protocol, including the EdgeTech acoustic modem, has overcome the limitations of operating an acoustic communication system in the shallow-water waveguide while achieving a robust, highly reliable data link. In recent years, the proliferation of acoustic communication and telemetry devices has enabled an opportunity for these new modem telemetry protocols. Several deployments in the near-shore, shallow-water coastal region of Florida have demonstrated the feasibility and utility of the protocol in meeting the objectives: transferring AUV navigational information, oceanographic parameters measured from onboard CTD sensors, and command/control of the AUV.

Protocol

The protocol is an open-channel architecture with predefined identification numbers assigned to each telemetry unit, which serve as unique network addresses. The acoustic modem employs a carrier sense multiple access collision avoidance (CSMA/CA) propocol that is adapted to the acoustic conditions found in the underwater envirinment. Each message contains a source and destination address, a binary data string, a redundant linear block code representation of the data, and redundancy for error detection and correction. In addition, each data message has a sequence number that is used to prevent duplicate copies of the same message from being received when the modem is in the retransmit mode.

Each acoustic modem keeps track of binary data message sequence numbers and maintains message queues for every other modem. This allows for multiple messages to be queued up in random order, and ensures they will be delivered to each modem in the proper order from a given unit. For example, if messages are transmitted from the local modem to remote units 1, 2, 2, 3, 2, 3, there will be delivered 1 message to modem 1, 3 messages to modem 2, and 2 messages to modem 3, in that order, but in proper sequence for each modem.

When a data message sent by a source modem is received without error by a destination modem, the remote modem will immediately send back an acknowledgment message (ACK). This ACK is checked by the source modem for correct source and destination addresses, check errors, and message sequence numbers. If no errors are detected, the source modem will continue by immediately sending the next data message in its queue. The host computer will be notified of the successful transmission. If the data message is not correctly received by the destination modem so that no ACK is transmitted, or in the case that the ACK is corrupted, the source modem will enter a retransmit mode after a predefined time-out. This process will continue until the number of retries (set during modem initialization) are exhausted, at which time the host computer will be notified that the message could not be delivered to its destination. Messages to other destination modems remain in the transmit queue, and are then sequentially transmitted.

When a modem enters the retransmit mode, it is assigned a priority-based time slot during which it is allowed to reinitiate an unacknowledged communication. The time-slot assignment is based on the modem priority number (usually equal to the modem ID) and provides a mechanism for message collision avoidance. However, the priority/time delays are adjustable and can be reconfigured in accordance with the maximum peer-

to-peer channel delay and desired telemetry unit time-slot assignments.

Each telemetry unit also monitors the energy in the channel and will not send a data message if there has been recent communication between other modems. This improves network throughput by allowing a modem that has been sending messages to finish sending all queued messages while providing a minimal probability of a collision.

Ocean Explorer AUV

The OEX AUV is a highly modular design, featuring a distributed communication and control network based on the open LONTalk network protocol, a modular power system, and modular payload capability. The modular design results in a field-reconfigurable vehicle that is well suited for the demands of AOSN. The hull shape of the vehicle is a hydrodynamically efficient modified Gertler shape with a maximum diameter of 21 inches. The standard hull configuration is 7 feet in length with optional hull extensions for increased payload capacity that can increase the overall vehicle length in excess of 10 feet.

Acoustic Modem

The acoustic telemetry system was developed by Edge Tech (formerly EG&G Marine Instruments) with assistance from the FAU Chirp-Sonar Laboratory. The design is based on a chirp-pulse multifrequency shift-keying (MFSK) signaling format. The original design uses a standard configuration of 56 individual chirp-pulse frequencies for transmission of 24 bits simultaneously. Each bit in the original design is represented by the customary two frequencies for FSK signaling, thus requiring 48 frequencies. Another four frequencies for packet counting and parity are used along with four unused frequencies reserved for future use. The MSFK modulation is implemented via a dedicated digital signal processor (DSP) chip interfaced to an embedded single-board Intel 80486 computer.

A key feature of the new communication protocol is the use of a dedicated DSP, this allows for considerable flexibility in configuring the frequency allocation to suit particular underwater waveguide boundary conditions. The DSP is used for continuous matched filter processing of the 56 channels thus improving the signal-to-noise ratio (SNR) by 6 dB. As applied to the command and control requirements, the flexibility of EdgeTech's modem is an important aspect of the OEX operational capabilities. When utilizing an underwater acoustic waveguide as a data telemetry channel, the expensive and complex OEX system (required to operate autonomously in the open ocean) requires communication redundancy and reliability over channel capacity. This is what the EdgeTech modem has achieved; the highest level of redundancy and reliability.

Modem Environmental Matching

The shallow-water acoustic waveguide of the near-shore region of South Florida is a junction of oceanic, coastal, and continental water constituents, consisting of Gulf Stream intrusions and counter-currents, intracoastal brackish water, rainwater runoff, and ground water seepage, resulting in a highly variable acoustic environment. In addition to varying waveguide conditions, other significant contributors in the near-shore region are the presence of biologically produced acoustic input such as snapping shrimp, and anthropogenic acoustic sources such as motorized pleasure craft, and low-frequency propagation from the heavy shipping lanes.

In order to optimize the performance of the acoustic modem in these conditions, the modem was tested with various combinations of the available 56 frequencies to identify the frequencies that are best suited to combating the effects of mode-stripping or amplitude fading, along with ambient noise contamination. The result is that a subset of 20 frequencies was selected from the available 56 for data transmission channels. The 20 frequencies were used four at a time, to transmit one bit at a time. Additionally, frequency-hopping was introduced to provide five different channel combinations in order to avoid reverberation. Therefore the tested implementation was a frequency-agile MFSK system.

The message redundancy coupled with the one-second token passing delay inherent in the acoustic modem/OEX interface (see following subsection) resulted in a maximum bit rate of 20 baud.

This low data rate is sufficient since a premium was placed on the reliability of the acoustic communications to ensure emergency handling and mis-

"Paramount to the effectiveness of the protocol is the inherently open nature of the communication channel as opposed to a dedicated master-slave architecture where 'connection' has to be made between telemetry units and then disconnected to enable communication between another two units."

sion intervention capabilities.

EdgeTech Modem Interface

The acoustic modem communicates with a host computer through a token-passing protocol. The token is the ASCII string: "READY\r\n." The device with the token is the only one allowed to initiate a communication sequence. Every received command returns a response: "REPLY X\r\n," where X is the 8-bit reply value that indicates status information concerning the reception and processing of the command. There is also a predefined set of commands that the modem and host computer can transmit to the other device. The command consists of an ASCII string of the form: "CMD arg1 arg2... argN\r\n", where "CMD" is the command identifier and "argN" is the nth command line argument which may be a character string, integer or floating point number. There are delimiting spaces "\x20" between arguments and terminating carriage-return linefeeds. The token-passing protocol used to communicate between the modem computer and the host computer on the OEX, or a PC on the surface ship, should not be confused with the CSMA based MFSK acoustic communication through the water between the modems onboard the OEX and surface ship.

Data, Command/Control Telemetry

The OEX was run on April 30, 1997 (15:41 to 16:26 EST) offshore Boca Raton, Florida with the AM transmitting positional information, temperature, and depth from the OEX to the R/V *Oceaneer*. The R/V was positioned via a single point mooring at: 26° 21.429'N, 80° 3.660'W; the sea-state was 1; and water depth, 45 feet. The OEX ran a variable depth "box" survey pattern covering a linear distance of approximately 3.6 kilometers encompassing a 0.4 square-kilometer surface area.

The data transmissions alternated between navigation waypoint number/vehicle heading, and vehicle depth/water temperature—for example, "W23 181 deg" indicating waypoint number 23 and vehicle heading of 181°, and "2m 26.0C" the representation for vehicle depth of 2 meters, water temperature 26°C. The depth and temperature data corresponding to the waypoint number was recorded onboard the OEX via the Scientific Inc. (Cataumet, Massachusetts) CTD sensor.

Acoustic communications were maintained even with the OEX operating on the surface.

Modem Improvements

Since the introduction of the original modem a new design has been developed and tested using a "one of eight" mode of transmission that improves SNR and signaling bandwidth. Reliability and baud rate improved to a range of 300 baud

(highest redundancy) to 2,400 baud (lowest redundancy). The modem hardware and software have undergone substantial improvements, which have evolved from our experience in using the protocol for over a period of one year.

A single Texas Instruments C32 DSP is now used for performing the signal processing and handling the data protocol with other modems and communication with the host. A new 2-kilowatt class D linear amplifier was custom designed to utilize power efficiently in driving the transducer and thus providing 192 dB source level with little harmonic distortion and low wasted power. Custom four-layer boards are used in the new modem design configured to fit in a 4-inch diameter tube.

The modem uses power management to minimize energy requirements and automatically operate over several redundancy levels thus providing the maximum communication rate for given channel conditions. Channel reverberation, noise levels, and vehicle range (determined from ACK timing) are constantly monitored and used to determine the required redundancy level. In the highest redundancy mode, the modem uses a frequency-hopped, single, one-of-eight mode of transmission with Bose-Chaudhuri-Hocquenqhem (BCH) correction (allowing for a maximum of 4 percent random error correction). Redundancy is modified by increasing from one-chirp pulse/signal interval up to 16 chirp pulses/signal interval thus providing signaling rates ranging from 300 baud to 2,400 baud. In tests offshore in water 10 meters deep at Boca Raton, the modem operated to 2 kilometers without any BCH detected uncorrectable errors and an accumulated number of BCH detected correctable errors of only 6 bits in 4,000 bytes.

EdgeTech is currently manufacturing four beta versions of the modem.

Epilogue

The CSMA protocol for AUV communications has several important features based on the underlying assumption that absolute reliability of a data or command transmission is more important than high channel bandwidth. Paramount to the effectiveness of the protocol is the inherently open nature of the communication channel as opposed to a dedicated master-slave architecture where "connection" has to be made between telemetry units and then disconnected to enable communication between another two units. This feature allows for reliable exception handling from the network command/control center since every telemetry unit has an opportunity to use the channel.

The protocol is adjustable in terms of the longest expected acoustic delay, in this manner the transmission and retry time-outs can be optimally adjusted to effectively match the waveguide properties. The protocol is also designed to avoid communication collisions via use of a carrier-sensing feature, and the associated transmission time-out. The protocol is also not constrained by the choice of communication signaling format, it is applicable to all amplitude, phase, and frequency modulation techniques. */st/*

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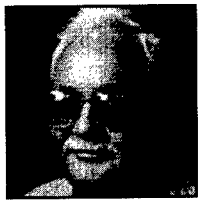
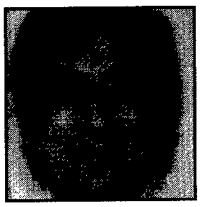
Smith, Samuel M., Stanley E. Dunn, Thomas L. Hopkins, Karl Heeb, Tom Pantelakis, "The Application of a Modular AUV to Coastal Oceanography: Case Study on the Ocean Explorer," *IEEE Oceans 95 Proceedings,* San Diego, California, pp. 1423-1432, October 9-12, 1995.

Smith, Samuel M., Stanley E. Dunn, Edgar An, "Data Collection with Multiple AUVs for Coastal Oceanography," Oceanology 96, Brighton, United Kingdom, March 5-8, 1996.

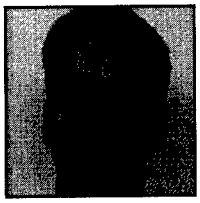
Alan F. Neel II, with 25 years of experience in computer architecture, data communications, and sonar-related fields, is responsible for new products in the areas of chirp sonar and acoustic-modem development. Neel earned a bachelor of science degree in electrical engineering from Texas Tech University (1970) and a master of engineering degree in electrical engineering from the University of Louisville (1972). He holds six patents in the areas of computers and data communications.



Dr. Lester R. LeBlanc was principal engineer at the Raytheon Submarine Signal Division (1966 to 1971) where he conducted R&D in underwater acoustic signal processing. From 1971 to 1990, LeBlanc became professor of ocean engineering at the University of Rhode Island. Since 1990, LeBlanc, as professor of ocean engineering at FAU, teaches signal processing and conducts research in underwater acoustic communication and acoustic seafloor sediment classification. He received a bachelor's of science (1962), master's of science (1963) and doctorate (1966)—all in electrical engineering at the University of Rhode Island.



Dr. Samuel M. Smith, associate professor of ocean engineering, FAU and director AMS Laboratory, currently, together with the AMS group, is conducting R&D in sensing, command, and control systems for AUVs. Other research includes network-control systems for shipboard automation. In 1991, Smith received a doctorate in electrical and computer engineering from the Department of Electrical and Computer Engineering at Brigham Young University (Provo, Utah).



Dr. Joseph C. Park, a faculty member with FAU, has over 10 years experience as an electronic and communication systems analyst and engineer for the U.S. Navy and private technology companies. His projects included designing and analyzing acoustic and electromagnetic communication and tracking systems, implementation of specialized signal-processing techniques, and measuring and analyzing oceanic and atmospheric physics. Park is developing software and integrating hardware for the OEX series AUVs. Park is registered professional engineer in the state of Florida.

SeaNet —Ship/Shore Communications

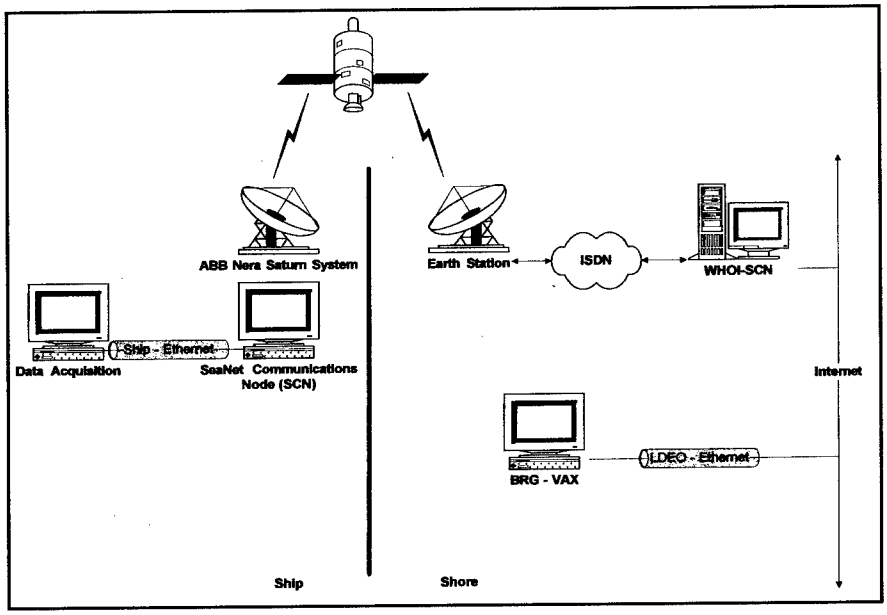
Extending the Internet to the Oceanographic Research Fleet; Prototype Successfully Tested on JGOFS Arabian Sea Cruise

By Dale Chayes
Project Engineer

Gregory Myers
Technical Coordinator
Lamont-Doherty Earth Observatory
Columbia University

and

Andrew Maffei
Information Systems Specialist
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts



Basic hardware configuration employed for the testing effort.

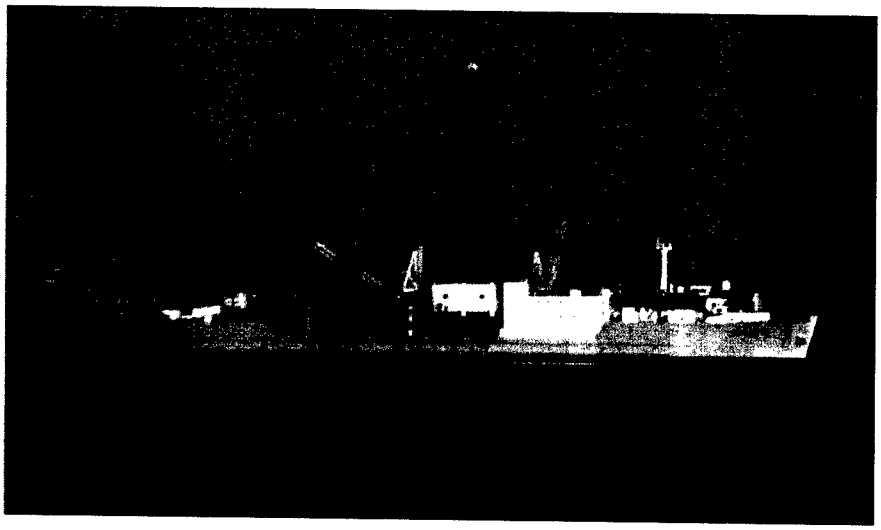
The Internet has insinuated itself so rapidly and pervasively into the scientific community and has become such a standard tool that many scientists already take it for granted. But not scientists working on research vessels in remote seas. For them, great expanses of ocean create a barrier for "logging on." A mundane task like retrieving e-mail whenever you want is not so routine when your office, temporarily at least, is bobbing in the Indian Ocean.

As early as the 1950s Maurice "Doc" Ewing, the founder of what is now the Lamont-Doherty Earth Observatory, recognized the value of communicating daily with his research vessel, the R/V *Vema*, to get timely news of what it found each day. In response, he could modify the ship's course or mission to maximize the scientific gain of each cruise—he didn't have to wait weeks for the ship to return to port to begin using the data. Today the vast amounts of data collected each day at sea by modern research vessels (not to mention the expense of operating these ships) exponentially increases the value of rapid, even near real-time, ship-to-shore data transmission.

To meet this challenge, we launched the SeaNet project, a collaborative effort to extend the usefulness of demonstrated oceanographic communication techniques through the application of standards-based network technologies. SeaNet's main purpose is to integrate communications technologies that have already proved useful to the oceanographic community, rather than to develop new communications links. A primary goal is to facilitate an infrastructure, or mesh, of communications links over (and through) the ocean using Internet protocols (IP), so that a combination of various telemetry methods can eventually be used to provide user-transparent links to at-sea computing platforms, or nodes. Using transmission control protocol (TCP)/IP protocols over an INMARSAT B link, the SeaNet Lite project developed and operated a working prototype that demonstrated on-demand Internet connectivity in remote ocean regions. We are now working to extend the Internet to the oceanographic research fleet.

Building, Testing a Prototype

In 1995, the Lamont-Doherty Earth Observatory's Borehole Research Group (BRG) initiated an effort to send wireline data acquired aboard the Ocean Drilling Program's (ODP) *JOIDES Resolution* to shore-based data processing centers via high-speed transmission. The goals were to decrease wireline data processing turn-around time, increase data quality control, and improve on-site decision making for safe and effective drilling.



Beginning with ODP Leg 166 in 1996, the BRG began using a very small aperture terminal (VSAT) to transmit logging data. While the system was very useful, it did not provide coverage in all major ocean regions and the antenna stabilization hardware was inadequate. These limitations led to discussions about using INMARSAT B with a high-speed data (HSD) option for SeaNet.

We devised a SeaNet communications node (SCN) built around a Sun Sparc 5 processor and an ABB Nera Saturn Bm (an INMARSAT-B shipboard Earth station). The SeaNet link employs PPP protocol over the entire link. The PPP protocol is carried on a synchronous digital link throughout the satellite-based segments and over an integrated services digital network (ISDN) connection on the shore-side link and TCP/IP across the shipboard local area network.

The SCN was first tested on shore. It was then shipped to Muscat, Oman so that it could be installed on the R/V *Thompson*, operated by the University of Washington. The SCN was installed during a port stop of the Joint Global Ocean Flux Study (JGOFS) program's study of the Arabian Sea. Co-author Andrew Maffei participated in a one-month leg of that study.

Initial Lessons Learned

Major accomplishments during this cruise included the successful integration of the SCN and INMARSAT-B subsystems into the *Thompson's* navigation system and proof that the system could work in both a batch and interactive mode to connect the shipboard LAN to the Internet.

One major lesson of the cruise was how important the INMARSAT-B antenna location was to the success or failure of the attempted connection to shore. Connections to the Internet were often impossible during the cruise because the ship's mast interrupted the path between the antenna and the INMARSAT satellite. When the ship changed heading to provide a better "view" of the satellite, the link worked reliably. However, this was often impossible due to the scientific requirements of the cruise.

"We successfully demonstrated the feasibility of on-demand Internet connectivity at sea."

Another lesson learned during the cruise was that it was important to "batch process" as many transactions as possible. The use of the link in an interactive mode proved to be too costly to be worthwhile. Our SeaNet budget had only limited communication funds for testing.

For our next deployment of the prototype system, we were looking for a science project on a ship that:

- Could be more flexible in its ability to change heading for short periods of time so that reliable Internet connections could be established
- Had an existing monetary budget for satellite transmissions in a more cost-effective manner.

The Ocean Drilling Program's ship, *JOIDES Resolution*, seemed like a good choice. We will report a more detailed account of this experiment in next month's issue, but in brief, we successfully demonstrated the feasibility of on-demand Internet connectivity at sea.

Future Plans

We plan to continue the use of the prototype SCN system on the *JOIDES Resolution* or on other research vessels that might have an immediate need for the capabilities that it offers. We still have more to learn about how best to tune the system to further improve transfer rates and about how to improve the user interface.

During the next phase of the SeaNet implementation we will be examining the lessons learned from experiences with this prototype to build a production-level SeaNet communications node. A SeaNet collaborative proposal entitled "SeaNet: Extending the Internet to the Oceanographic Research Fleet" was recently submitted in response to the 1997 National Ocean Partnership of the Office of Naval Research and will receive funding.

Over the next two years the SeaNet collaborative, employing lessons learned with our prototype system, will build a shore-side and shipboard infrastructure to support the connection of ships to the Internet using wireless technologies. The funding will enable the SeaNet partners to create the shore-based and shipboard infrastructure capable of supporting both a high-speed (e.g., INMARSAT-B HSD at 64 kilobaud) and low-speed (e.g., cellular or PC's modem at 4,800 baud) access to the Internet from ships at sea.

The infrastructure includes:

- Building a shore-based operations center
- Providing updated satellite and cellular communications for a number of UNOLS vessels
- Developing shipboard communications servers designed specifically for the support of shipboard science and technical support applications
- Supporting the integration of emerging (less expensive) communications technologies in the future.

Once this infrastructure is in place and operational, the incremental cost of adding more ships to the SeaNet network should be relatively small. A SeaNet advisory panel will provide guidance and advice to SeaNet opera-

Data Sample of Shipboard Test

Date	*File Size Kilobytes*	*Time Seconds*	*Rate kbps*	*Direction*
Nov 15	3164672	840	3.77	Shore-bound
Nov 19	7872512	1752	4.49	Shore-bound
	79730	20	3.99	Shore-bound
	74032	19	3.90	Shore-bound
	81284	24	3.39	Shore-bound
	73660	22	3.35	Shore-bound
	74547	24	3.11	Shore-bound
	68892	20	3.44	Shore-bound
	274307	72	3.81	Shore-bound
Dec 2	7276544	1684	4.32	Shore-bound
Dec 6	770048	468	1.65	Ship-bound
Dec 8	3122560	697	4.48	Shore-bound
	770048	456	1.69	Ship-bound

tions, including recommending ships for SeaNet installation. We plan to make this a community effort involving the support staff at the various oceanographic research organizations. Our hope is that the resulting network will eventually be self-supporting.

Other Communications Node Designs

Although we have been quite pleased with the modular design of the SeaNet Communications Node, we have identified several possible improvements to the design for a production unit. First, we believe that the hardware and software required for the SCN can be greatly simplified by moving from the SUN Sparc 5 hardware platform running Solaris(tm) to a PC platform running Linux(tm). Many of the software tools we had to port to Solaris come as part of Linux. Linux also has a wide variety of communications tools that will be useful for the project, including packet-level cost accounting and IP masquerading, among others. IP masquerading would allow a ship to use a single IP address for the entire shipboard LAN.

We also think that some of the satellite communications link management and control functions might be moved off the SCN to a smaller dedicated router with some INMARSAT-B specific functionality. If this proves cost-effective, similar dedicated routers might be added for each future wireless communications interface (cellular radio, Iridium, AMSAT, etc.). The SCN, acting as the general shipboard router, would then be responsible for determining which wireless communications interface is active and for routing packets to the appropriate dedicated router.

We would like to identify a commercial source for these dedicated routers, if at all possible.

While the SeaNet collaborative has spent the last two years developing and testing the SCN, the Navy, during the same time period, has been busy

with its own Internet at Sea program. Although the Navy system is based on more expensive hardware and software components, it is possible that some of the components might be ported to the SeaNet SCN design as well. We are actively reviewing the Navy design to determine which parts of the design it will be worthwhile to incorporate into the SCN.

Cost-Effective E-mail at Sea

It has also become clear to the SeaNet collaborative that at the very least, the project must make the transmission of shipboard electronic mail more cost-effective. A first step toward this goal will be to bring together groups of technical support personnel at various research organizations that have been working on shipboard e-mail systems for many years.

We plan to hold a workshop that will have three goals:

- To identify the features of existing shipboard e-mail systems
- To build a specification describing necessary features for a shipboard e-mail system
- To create an ongoing forum for shipboard e-mail developers to meet and discuss their experiences with shipboard e-mail and how to improve it.

We hope that the draft specification that emerges from the workshop can be used as a working document to help identify common e-mail clients and servers for shipboard e-mail use. The SeaNet collaborative would then use this specification to build the support for these e-mail components into the SeaNet shore-side and shipboard infrastructure.

As these goals come to fruition in the near future, our vision is that Internet connections to and from ships at sea will become a normal part of oceanographic research. */st/*

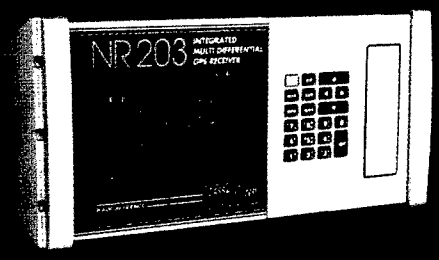
Dale N. Chayes has worked at Lamont-Doherty since he graduated from St. Lawrence University in 1973. He has participated in more than 100 research cruises. A project engineer for the design and development of shipboard geophysical instrumentation and data acquisition systems, Chayes was a principal in the development of data systems for the R/Vs Conrad *and* Ewing.

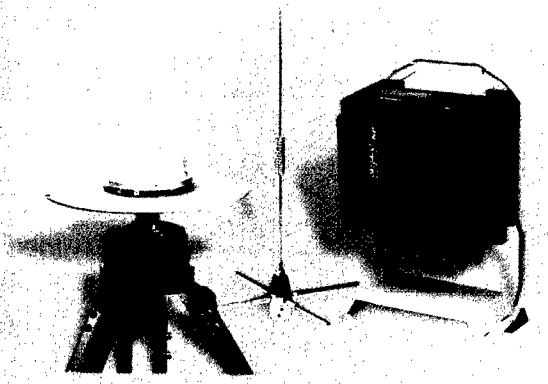
Greg Myers is presently serving as the BRG technical coordinator at the Lamont-Doherty Earth Observatory. Myers attended Rutgers University and has since contributed to the field of borehole geophysics on many levels including field service, data analysis, tool research and development, and new technology integration. He has participated in three ODP Legs and is an active member of the Society of Professional Well Log Analysts.

Andrew Maffei specializes in data communicaitons and network support for scientists at the Woods Hole Oceanographic Institution. Since he started at WHOI 15 years ago, he has wondered why it is possible to transfer digital images and make course corrections with vehicles such as the unmanned Voyager spacecraft but it is so difficult to perform similar functions with research vessels and buoys at sea. The SeaNet project offers him an opportunity to learn the answer to that question.

AQUARIUS

SURVEYING TOOLS





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New York Catskill Reservoir Surveys

Application of Marine Technology to Freshwater Reservoirs; Surveys of and Bottom Samples from Seven Reservoirs Obtained

By John H. Ryther, Jr.
Marine Operations Manager

Steven G. Harris
Captain of S/V,
Oceanographic Technician
CR Environmental Inc.
East Falmouth, Massachusetts

and

Christopher F. Wright
Environmental Scientist
GZA GeoEnvironmental Inc.
Newton Upper Falls, Massachusetts

***Below is S/V pilot house.Above, S/V* Cyprinodon.**

The New York City Department of Environmental Protection (NYC-DEP) needed to perform extensive geophysical surveys at seven reservoirs in the New York Catskills to support ongoing reservoir hydrodynamic and eutrophication modeling efforts mandated by the U.S. Environmental Protection Agency (EPA). The Catskill reservoirs are part of a system that provides 9.5 million people with 1.5 billion gallons of water per day. Therefore the data was needed quickly in order to assess potential sources of nutrient contamination in the watershed of the city's drinking water supply. To meet this challenge, a highly qualified team of scientists, engineers, and technicians from GZA GeoEnvironmental, CR Environmental, and the Ecosystems Center, Marine Biological Laboratory (MBL) (Woods Hole, Massachusetts) were contracted to perform bathymetric and sediment mapping, as well as a physical and chemical characterization of bottom sediments of the reservoirs.

The Task

This was no small job—the seven reservoirs of the Catskill/Delaware system: the Cannonsville, Pepacton, Neversink, Ashokan, Scoharie, Rondout, and West Branch, ranged in size from 1,000 acres with a maximum depth of 50 feet (West Branch), to approximately 8,000 acres and a maximum of 190 feet (Ashokan).

To meet the tight schedule and perform the extensive survey and sampling operation on a limited budget,

the team took the unique approach of transferring marine technology to a fresh water environment. The project team had strong management and field logistics experience on nearshore and large offshore marine operations. The project vessel was specifically designed for marine survey operations, and the survey equipment and software used were state-of-the-art—proven systems developed for dredging and oceanographic survey projects.

From May to September 1997, the Catskill geophysical survey and sediment sampling operations were performed with essentially no weather or equipment downtime.

Survey Vessel

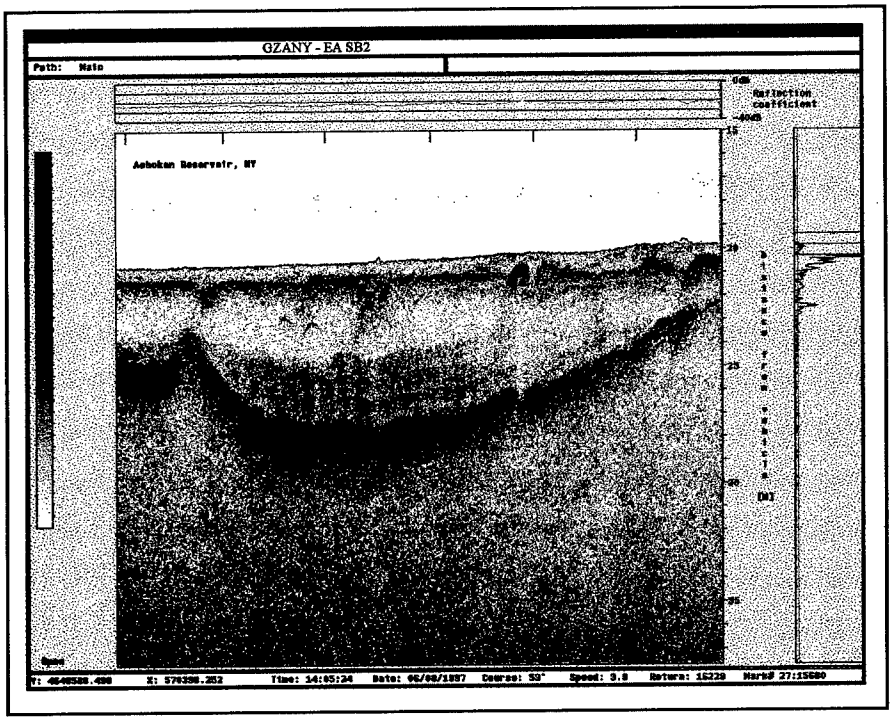
CR Environmental's 32-foot aluminum survey vessel, *Cyprinodon,* was the base for the operation. *Cyprinodon* was ideal, as she provided a large stable platform and could be operated in less than a meter of water. The vessel had a large pilot house with built-in benches and shelves for survey equipment. A diesel inboard allowed low-speed operations and low fuel consumption, and a dual-propeller drive offered maneuverability. A 5 kW 110 volt SeaPower generator which ran off the main engine provided sufficient clean power for all the survey equipment, and a 1,000-pound capacity hydraulic winch and A-frame were used to deploy and recover the sub-bottom towfish, grab sampler, and box corer used on the project. *Cyprinodon* also had a removable transom which created an open stern and work deck, and ballast tanks to trim the vessel against the load of various equipment. In addition, *Cyprinodon's* light aluminum construction and shallow draft enabled the vessel to be transported over the Catskill mountains between reservoirs, and launched into the flooded river valleys on dirt and gravel roadways using a diesel pick-up and triple-axle trailer.

Although *Cyprinodon* was designed for near-shore coastal survey operations, half its operating hours have been spent on fresh water systems. Prior to the work in the Catskills, the vessel was used during an extensive side-scan and sub-bottom survey of the Quabbin and Wachusett reservoirs in Massachusetts. Side-scan sonar was used to map the former towns beneath these reservoirs and identify potential sources of mercury pollution.

Fantail operations.

Survey Equipment

It was important that the equipment used by the team be accurate and reliable because detailed maps showing bathymetric contours, bottom profiles, and shoreline features were essential for the hydrodynamic modeling effort.



Sub-bottom layers of the Cannonsville Reservoir obtained with the Edgetech X-Star - sub-bottom profiler.

After all, the reservoirs range in age from 35 to 80 years, and their bottom configurations have undoubtedly changed, casting doubt on the accuracy of recorded reservoir volumes.

Operations were performed so far from coastal waters that U.S. Coast Guard beacons could not be received. Therefore, navigation for the survey and sampling operations was performed using a Trimble Navigation Ltd. (Sunnyvale, California) Pro-XL GPS interfaced to an Omnistar Inc. (Houston, Texas) 6300A receiver, a differential correction receiver used widely for forestry and agricultural applications. The Omnistar system consists of 10 permanent base-stations in the Continental United States and one in Mexico. The 11 stations track all the GPS Satellites above 5° elevation and compute corrections every 600 milliseconds. These corrections are sent to the Omnistar Network Control Center (Houston, Texas) where they are checked, compressed, and formed into a packet for transmission to Omnistar's satellite transponder. Every 2 to 3 seconds, Omnistar users receive these packets of data from the satellite transponder. The data is then decoded and corrected for atmospheric errors. Using this system, submeter horizontal accuracy was achieved on the Catskill surveys. Although there is an $800/year subscription for the Omnistar service, using this system eliminated the requirement for setting up local base stations and radio links at the reservoirs to transmit differential correction to the vessel, saving the manpower that would have been necessary to move stations and provide horizontal control.

Bathymetric data was collected using a 200 kHz Raytheon DE-719D precision echosounder, a new state-of-the-art digital echosounder with a thermal printer and digital output, housed in the same rugged aluminum case of the former Raytheon DE-719 sounders. This system has a fully sealed input keypad/LCD display and low-power consumption, making it an ideal echosounder for small boat use. During the reservoir surveys, the transducer was mounted on an adjustable side-mounted boom which could be raised and lowered to achieve the best data quality. The GPS antenna was mounted over the boom to eliminate positional offsets. This system was virtually automatic, extremely easy to use and calibrate, and highly reliable over the four-month survey.

The sediments in the seven reservoirs were mapped using the EdgeTech (Milford, Massachusetts) X-Star sub-bottom profiler and SB-424 towfish. This system has been used successfully by CR and GZA on several marine applications including harbor dredging projects and for sediment mapping at dredged materials disposal sites. The EdgeTech Model SB-424 towfish has a chirp bandwidth

of 4 to 24 kHz and a 10-millisecond pulse length. This frequency and pulse length provided an optimum vertical resolution of 8 centimeters, and penetration of 2 meters in sand and 5 meters in silt, which proved to be ideal for measuring the thickness and extent of the reservoir sediments. Sub-bottom profiles were printed on an Alden Electronics Inc. (Westboro, Massachusetts) thermal printer and recorded on EXABYTE tape. The sub-bottom towfish was raised and lowered using Cyprinodon's hydraulic winch and A-frame and maintained at a depth above the bottom which maximized data quality, yet precluded potential collisions with submerged obstacles or geologic features.

The DGPS, echosounder, and sub-bottom data were interfaced to an onboard computer loaded with Coastal Oceanographics Inc. (Middlefield, Connecticut) HYPACK hydrographic surveying software. This system calculated and displayed x-y positions in the UTM Zone 18 (1927) datum, recorded the depth and navigation data, and output x-y positions to the sub-bottom profiler.

DXF outline files of the reservoirs were imported into the HYPACK program and grids of lines were created to match the lakes' irregular shapes. The survey vessel's built-in video monitor provided the helmsman with a display of the outline of the reservoir, as well as a real-time vessel position relative to the grid of planned survey track.

Operations

One of the most challenging aspects of job was launching and retrieving the vessel on the former roads leading into the reservoirs. Prior to launching the vessel in any of the reservoirs, it was transported to a NYCDEP operations office where the hull and sampling equipment were steamed cleaned for protection against Zebra Mussels. At some of these sites, gates had to be moved, brush and branches cleared, and six inches of mud removed. To launch the vessel, a dual-wheel diesel pickup would back down a narrow dirt path and push the trailer into water deep enough to float *Cyprinodon.* Because of the shallow road grades, the truck was often submerged to its doors before the vessel floated free. Hauling the vessel was even more challenging, and a second diesel pickup truck with a tow line was often required on the softer surfaces.

Once the vessel had been launched, the first task was to locate a safe anchorage and then set a mooring consisting of a 100-pound kedge anchor, 1-inch line, and a polyform ball. Although these reservoirs were inland, mountain weather is unpredictable and 2- to 3-foot seas during storm events was not unusual.

For the geophysical survey operation, tracklines with 100-meter line spacings or less were run along the lengths of the reservoirs in water as shallow as 2 to 3 meters. In addition, a series of perpendicular cross-tie lines were run across the reservoir basins. Stone walls and building foundations from the former towns beneath these reservoirs were detected on the bathymetric and sub-bottom records.

Local inhabitants would often park on the dams above the reservoirs and stare in disbelief as *Cyprinodon,* the biggest boat ever to float on the lakes, towed a torpedo-shaped device, methodically back and forth across a reservoir. Undoubtedly, they believed that the crew was sampling some of the large lake trout and salmon that

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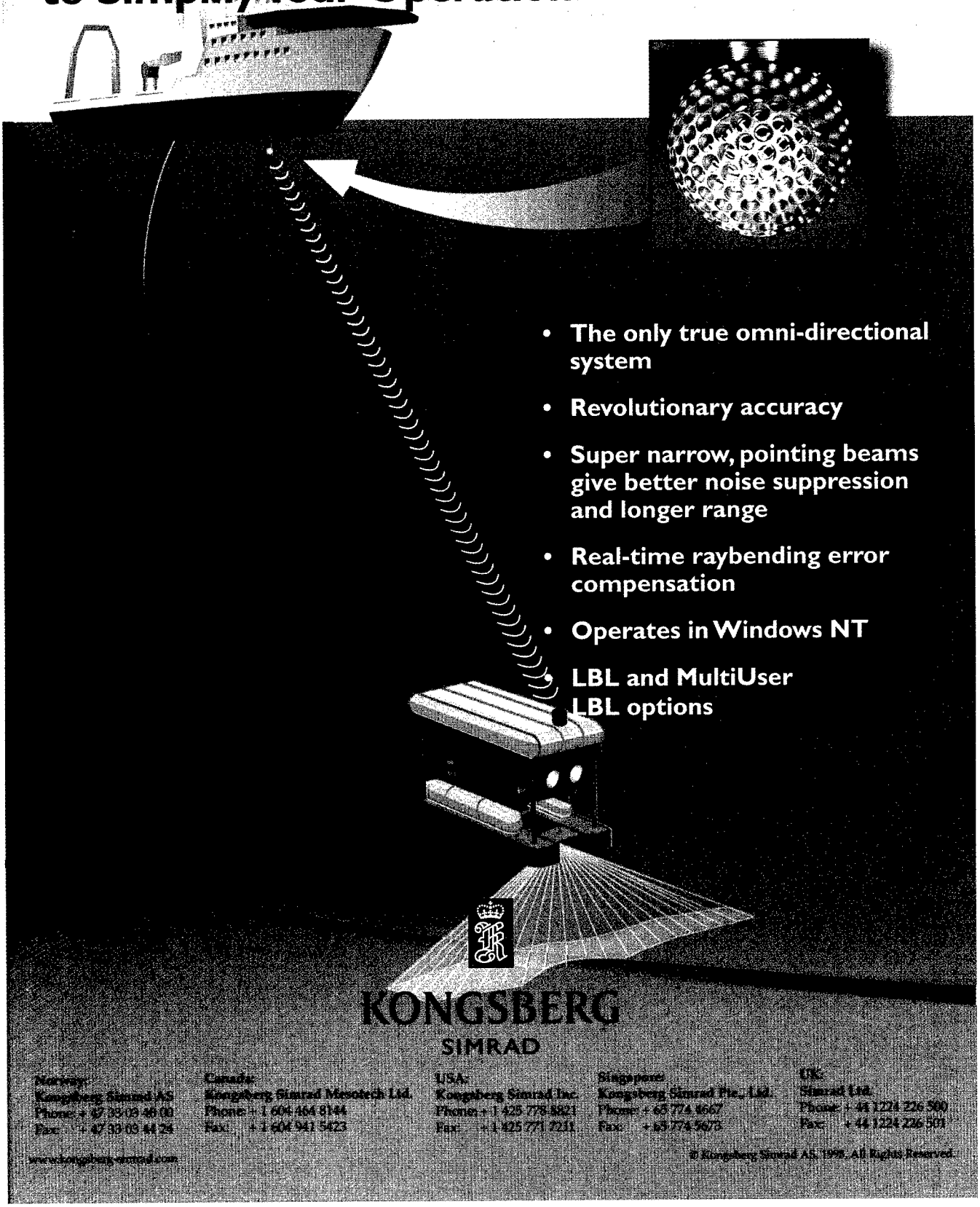

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inhabit the depths of these reservoirs.

At the completion of the geophysical survey operations in each reservoir, the bathymetric and sub-bottom data was examined, and depositional soft bottom areas were selected for potential bottom grab and coring sites.

Sediment Sampling

Bottom grab samples for sediment characterization were collected with a modified van-veen grab sampler [Ted Young (Sandwich, Massachusetts)]. This grab sampler is used exclusively by most research institutions and oceanographic consulting firms on marine benthic monitoring programs. It is extremely reliable and rarely misfired on the Catskill project. The grab sampler, with a large surface area, collects a large volume of sediment. Four 2-inch diameter subcores were collected through the upper doors of the sampler and the top 2 centimeters of sediment were placed in whirlpack bags and maintained on ice. With the sediment sampling stations displayed on the survey vessel monitor, the captain would reposition the vessel to within a few feet of the required position during grab samples.

Using *Cyprinodon's* hydraulic winch, A-frame, and the Ted-Young grab sampler, three replicate grabs at each sampling station could be collected and processed in less than an hours time, enabling the crew to sample up to 10 sediment sampling stations per day. After collection, sediments samples were frozen and sent to the GZA and MBL labs where they were analyzed for particle size, organic and inorganic carbon, nitrogen, phosphorus, chemical oxygen demand, clastics, and calcium carbonate.

Box cores were also collected at specifically chosen grab sites using a Gray-O'Hara box corer [Contentintal Shelf Assoc. (Jupiter, Florida)], a modified Sutar-type box corer which is often used on harbor and nearshore monitoring programs. These cores were obtained for benthic-flux measurements to determine if phosphorus was being released by the reservoir sediments. These undisturbed cores, up to one foot in length with overlying water, were transported to GZA's field laboratory where they were placed in a dark incubator and held at the *in-situ* water temperatures. Sediment oxygen consumption was monitored in the cores, and water samples were frequently collected to determine whether phosphorus was being released to the water column after the onset of anoxia.

For a base of operation, GZA rented a log-cabin house on the side of a mountain in West Kill, New York, located equidistant from the seven reservoirs. The basement was set up as a laboratory for the benthic flux measurements, for the storage of sediment samples, and for the geophysical data processing. This was also the home for the four- to five-man survey team for the four month duration of the project.

GZA and CR field crew would be up at daylight and would have a scenic one-to two-hour commute to the work site. After a 10- to 12-hour day of running tracklines or sediment sampling, the field crew would return at dusk to the cabin in the woods. By no means did the work day end here. Throughout the night technicians would be measuring oxygen levels in the benthic flux cores. Field scientists would be editing survey tracklines, digitizing sub-bottom records, or preparing equipment for the next survey day. The one day off at the end of the week was well deserved, often spent trout fishing in one of local streams or hiking on mountain trails.

This day would end looking over a waterfall that drained into Schoharie, drinking a beer and eating a 32-ounce steak at the local biker bar called Nick's Water Fall House.

By early September, the field work had been completed and the vessel *Cyprinodon* with four months of near continuous use and over 1,000 hours of operation was transported back to Massachusetts for maintenance. At the GZA cabin, however, by no means was the work over, as the benthic flux measurements and the geophysical data processing continued through the end of September. By early October, GZA field scientists and draftsman were preparing the final products for NYCDEP including detailed bathymetric contour maps, sediment classification maps, and sediment isopach maps of the seven reservoirs. In addition, electronic files were furnished to NYCDEP for input into their GIS database. The sediment chemistry data is presently being examined and the project team will provide NYCDEP with written analysis of the spatial variations in sediment characteristics within and among reservoirs, and correlation of sediment quality with such factors as reservoir age, flow, watershed soil type and trophic status.

To gather the data required for these analyses, over 1,500 line miles were run with the survey systems, 1,000 sediment grabs were collected, and 100 box cores were taken from the seven New York reservoirs. In spite of the workload and isolation, the survey crew was able to appreciate the bald eagles, wild turkeys, beaver, bears, and deer that animated the dramatic Catskill vistas, and the field effort was completed two weeks ahead of schedule, at least partly due to *the successful transfer of marine technology to a freshwater system. /st/*

John H. Ryther, Jr. has over 20 years of experience providing logistic and technical support on oceanographic and limnological field operations. Formerly he was a senior oceanographic technician and program manager at EG&G WASC Oceanographic Services and Battelle Ocean Sciences. Ryther participated in the design and outfitting of the vessel Cyprinodon. *He also served as a consultant to GSA on the Catskill project to design the field program and providing survey and sampling equipment and logistic support.*

Christopher F. Wright, part of the risk management group of GZA, was chief scientist on the Catskill survey and was responsible for the geophysical data acquisition and processing and supervising the benthic flux experiments. In addition to his experience on fresh water and marine geophysical surveys, he has experience in soil microbiological analyses, assessments of contaminant attenuation and bioavailability, invertebrate taxonomy, and bioassessment studies of contaminated soils and sediment and wetland and limnological analyses and surveying.

Steven G. Harris has extensive experience in running surveys lines during geophysical operations and in the use of GPS navigation systems, precision echosounders, and HYPAC survey software. He has 12 years of offshore marine experience working on a variety of vessel types: sailing, research, a gillnet fishing vessel, and factory trawler. Harris is also a freelance writer on outdoor and environmental issues.

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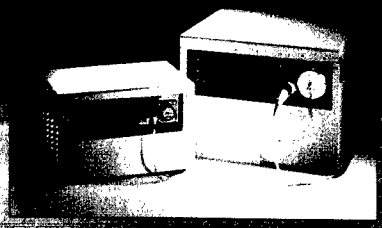

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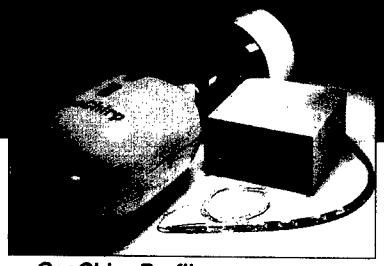

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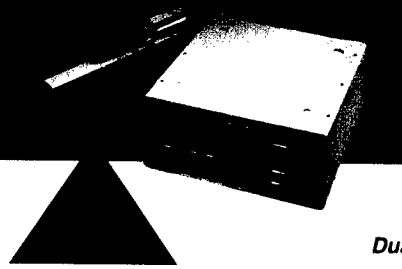

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THE PULSE OF SOUND TECHNOLOGY

Digital Acoustic Voice Communications

Digital Underwater Acoustic Voice Communication Long Overdue; Thinking Through Physics & Technologies Yields Viable Prototype

By Dr. Hayri Sari
Research Assistant
and
Professor Bryan Woodward
Professor of Underwater Acoustics
Department of Electronic and Electrical Engineering
Loughborough University
Leicestershire, U.K.

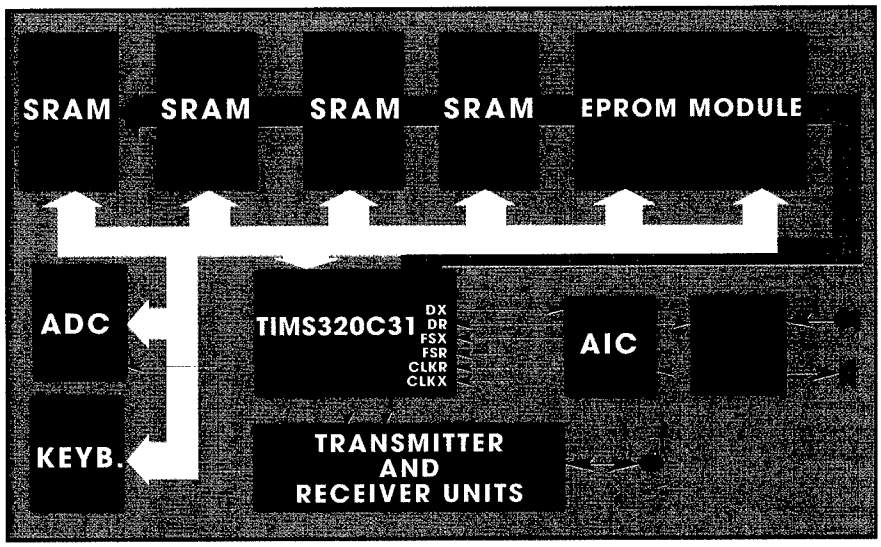


Diagram of prototype digital underwater acoustic voice communication system. SRAM = static random access memory; EPROM = erasable programmable read only module; ADC = analogue to digital converter; KEYB. = keyboard; TMS320C31 = Texas instrument digital signal processor; AIC = analogue interface circuit. The block in the middle row, right-hand side represents the microphone preamplifer and earphone driver. The data flow from AIC to the DSP is DR (data receive), FSX (frame synchronization pulse for transmit), FSR (frame synchronization pulse for receive), CLKR (serial port receive clock), and CLKX (serial port transmit clock); the data flow from the DSP to AIC is DX (data transmit output). The broad arrows indicate the 8 slots.

In an age of rapidly advancing technology, the design of diver communications systems remains virtually unchanged after more than three decades. The question might be asked, "Can a diver be provided with the communications capability of a digital mobile telephone?" This article attempts to answer that question and offers an insight into future progress.

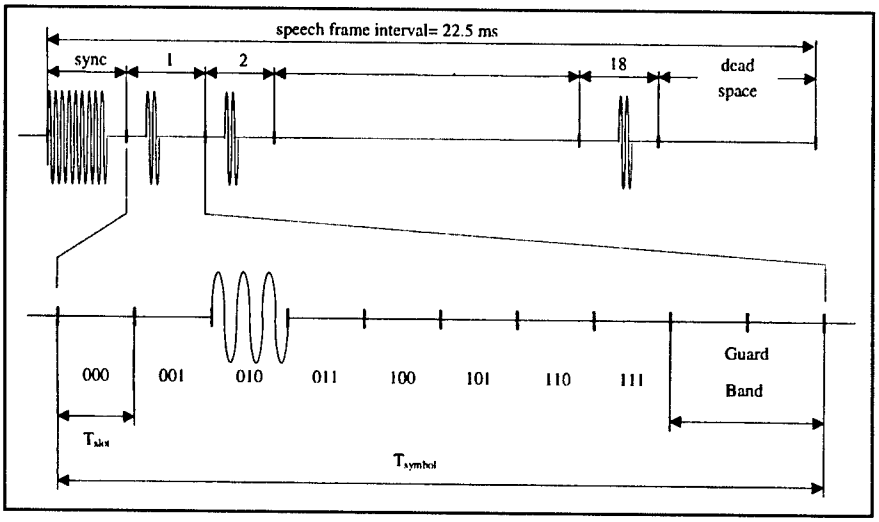
Unlike a conventional radio communication channel, the transmission of information through water is dominated by a variety of factors that limit the data rates achievable. These channel characteristics include path losses due to geometrical spreading and absorption, multipath effects caused by surface and bottom reflections, sound-speed variations, ambient noise, and distortion in amplitude, frequency, and phase. In addition, voice distortion may be introduced depending on the type of microphone, the shape of the mask and the breathing gas constituents. To enhance speech quality, this distortion must be offset and effects such as bubble noise and breathing noise must be cancelled or minimized before transmission.

Again unlike for radio channels, there is no legislation on the use of frequency bands underwater. In principle, any carrier frequency can be chosen, although it is advisable to avoid the recommended emergency frequencies for manned submersible beacons (10 kHz), hazard markers (13 kHz) and diving bells (37.5 kHz) and also the carrier frequencies of communications systems used by NATO (8.0875 kHz), commercial submarines (25 kHz), the Royal Navy (40.2 kHz) and the NATO Navies (42 kHz). Frequencies of the order of 40-42 kHz have been commonly used for analogue speech communication systems between divers and between divers and the surface to give a communication range of up to 1 kilometer, depending on the transmitter's output power.

In practice, the choice of carrier frequency is mainly determined by attenuation. The general rule is that the lower the frequency, the greater the range of transmission achievable, since range is inversely proportional to the square of frequency. Another factor that governs the choice of frequency is the effect of ambient noise, which is more noticeable at low frequencies, particularly in the audible range.

Digital Signal Processing

One reason for the need to adopt digital signal processing techniques is that there are limitations to the present analogue systems. One advantage of the digital approach is the possibility of a "private" communication link between divers or between a diver and the surface to obviate unwanted cross-



Transmission of digital data in DPPM format with 22.5 millisecond frame interval. The lower half of the figure shows the data frame duration (T_{symbol}) broken into data slots, each of duration T_{slot}.

talk with any other divers in the same area. Although this is possible in principle with analogue techniques such as double sideband suppressed carrier (DSBSC) and single sideband (SSB), there is practical limit to the number of carrier frequencies that can be accommodated in the bandwidth of the transmitting and receiving transducers—by contrast this can be overcome by using digital techniques.

To achieve real-time, digital underwater acoustic voice communications, coded speech samples must be transmitted and received by implementing a suitable digital modulation and demodulation technique. This requires the use of a digital signal processor (DSP) to implement the complex signal processing computations. The system we have designed operates in two modes. In its transmission mode, the system digitizes the "raw" analogue speech signal, compresses the resulting samples, encodes the compressed speech parameters, and transmits the information using digital pulse position modulation (DPPM). In its receive mode, it decodes the speech parameters and synthesizes the resulting speech signals to generate analogue speech.

The system architecture may be described as both a transmitter and a receiver with associated speech processing algorithms. The transmitter consists of a keypad unit, a speech preprocessing circuit [preamplifier, antialiasing filters, and analogue-to-digital (A/D) converter], a power amplifier, and an omnidirectional transducer. The receiver uses the same transducer, preamplifier, bandpass filter, envelope detector, and A/D converter. At the speech output end, postprocessing is achieved with a digital-to-analogue converter; lowpass filter and amplifier are also provided. A 32-bit TMS320C31 (33 MHz) Texas Instrument DSP is used because of its high performance in complex mathematical and fast signal-processing applications. It is a "third generation" device that is capable of exe-

Selected Acronyms

ADPCM	Adaptive differential pulse-code modulation
ASK	Amplitude shift keying
CELP	Code-excited linear prediction
Codecs	Coders-decoders
DM	Delta modulation
DPPM	Digital pulse position modulation
DSBSC	Double sideband suppressed carrier
DSP	Digital signal processor
FSK	Frequency shift keying
LD-CELP	Long duration-CELP
LPC	Linear prediction coding
PCM	Pulse-code modulation
PPM	Pulse-position modulation
PSK	Phase shift keying
Q	Quality factor
QPSK	Quadrature phase shift keying
RPE-LTP	Regular pulse excited—long-term prediction
SSB	Single sideband
VCELP	Vector code-excited long-term prediction

Modulation Techniques versus Bandwidth Efficiency

Modulation Technique	*Slots (M)*	*Bandwidth Efficiency*
ASK	2	0.5
	8	1.5
PSK	2	0.5
	8	1.5
FSK	2	0.25
	8	0.1875
DPPM	2	0.1875

cuting 33.3 million floating point operations per second (MFLOPS). Speech signal conditioning and digital or analogue conversion are achieved with a Texas Instruments application-specific speech codec TLC320AC01 analogue interface circuit (AIC).

In principle, digital encoding of speech can be achieved by any of the well known modulation techniques such as pulse-width modulation (PWM), pulse-position modulation (PPM), and delta modulation (DM). There are also several internationally recognized speech encoding techniques, such as 64 kilobit/second pulse-code modulation (PCM) and 32 kilobit/second adaptive differential pulse-code modulation (ADPCM), which are classified as waveform coders. Although they produce high quality speech, they are inadequate in terms of spectrum efficiency when applied to newer bandwidth-limited communications, for example satellite communications, digital mobile radio, private networks, and especially underwater communications. There are also severe problems meeting the sampling rate requirement for speech signals.

Since the speech bandwidth for telecommunications applications is about 3,200 Hz (range: 200 Hz to 3,400 Hz), the minimum sampling rate needed for recovery of a digital signal back to its original analogue form is at least twice this, i.e. about 8 kHz. The corresponding sampling period is therefore 125 microseconds; so in the case of using waveform quantization techniques like PCM, DM, and ADPCM, this is the maximum time allowed to transmit the encoded information. The limitation lies in the transducer used, which for our system has a resonance frequency of 70 kHz and quality factor (Q) of 5. What this means is that of these techniques only ADPCM, with a data rate of 16 kilo-

Digital Underwater Voice Communications Carrier Frequencies (kHz)

Speech Encoding	*Bit Rate (kilobits/ second)*	*Modulation Method (8-Slot DPPM)* ASK & PSK f_o	FSK f_o-f_1	QPSK f_o	PPM f_o
PCM	64	320	320-448	160	1066.6
ADPCM	16	80	80-112	40	266.6
LD-CELP	16	80	80-112	40	266.6
RPE-LTP	13	65	65-91	32.5	216.66
VCELP	8	40	40-56	20	133.33
CELP	4.8	24	24-33.6	12	80
LPC10	2.4	12	12-16.8	6	40

bit/second and a bit period of 62.5 microseconds, may be worth considering. A "rule of thumb" is that the bit period should be about Q times greater than the carrier waveform period.

Parametric Speech

It is evident from these considerations that waveform coders are not suitable for underwater acoustic voice communications, other than if a very high carrier frequency and wide-bandwidth transducer are used for very short ranges. Since bandwidth is severely restricted in underwater acoustic communications, low-rate transmission is essential, hence the necessity of adopting a parametric speech coder that compresses the speech information into a few "parameters" that are suitably encoded for transmission.

Amongst the parametric techniques, the FS1015 LPC10 speech coding (linear prediction coding) standard, at the bit rate of 2.4 kilobit/second, is used for military communications. Because of the inherent limitations of this standard, principally its simplified speech production model, good quality voice communications are not achievable. To improve speech quality and keep the bit rate lower than that for waveform coders, other coding techniques, using hybrid codecs, are available that use speech production models and waveform information. The FS1016 CELP (code-excited linear prediction) standard is mainly used for secure military communications at a rate of 4.8 kilobit/second, and the RPE-LTP (regular pulse excited—long-term prediction) standard, at a rate of 13 kilobit/second, is implemented by Group Special Mobile (GSM) as a standard in Europe. There is also half-rate GSM using VSELP (vector sum excited linear prediction) coding at a rate of 5.6 kilobit/second. These hybrid codecs produce good quality speech and have been successfully

applied in mobile communications.

Parametric speech coding techniques are feasible to accommodate underwater acoustic voice communications due to their low data rate. In our prototype system, the LPC10 vocoder (voice coder) is used, despite having comparatively poor speech quality, since it has the lowest complexity and the lowest data-rate. Its performance can also be increased by introducing extra functions that are used in the hybrid coders. In linear prediction coding, the excitation and all-pole linear-filter coefficients and gain parameters are estimated from a given speech signal sequence and quantized to achieve the transmission rate of 2.4 kilobit/second.

Modulation

In addition to speech coding, an appropriate modulation method is needed to transmit the encoded speech parameters. Of the digital modulation techniques that have been frequently used for underwater telemetry, the candidates for voice communications are amplitude shift keying (ASK), frequency shift keying (FSK), and phase shift keying (PSK). ASK is satisfactory when the channel exhibits little reverberation, as is the case for vertical propagation. In a noisy channel the performance of ASK can be improved by introducing an error correction scheme but this decreases the data rate. The problems associated with amplitude modulation in a reverberant environment are well recognized, and most underwater communication systems therefore use some form of FSK and PSK. FSK is generally suitable for long-range channels exhibiting rapid phase variations because it is more immune to multipath propagation, however PSK achieves better signal-to-noise ratio and is a more frequently applied technique for underwater communications. With PSK, digital data is represented by a phase change, so at the receiver, coherent detection is required so that the phase information of the input signal is recovered; however, its implementation is more complex than the other modulation techniques. Another shortcoming of PSK is its sensitivity to multipath propagation, which causes phase and amplitude changes. In order to overcome coherent detection complexity, differential PSK (DPSK) has been developed and high-rate data transmission, up to 20 kilobit/second, can be achieved with a directional array. In recent years, phase-coherent communications using 4-PSK and 8-PSK have been demonstrated to be viable methods of achieving data transmission through underwater channels, at rates of up to 10 kilobit/second.

In order to suppress the intersymbol interference problem due to multipath propagation for ASK and FSK, existing non-coherent systems employ signal formatting with guard times. They are inserted between successive pulses to ensure that all the reverberation disappears before each subsequent pulse is received. The insertion of idle periods of time obviously results in a reduction of available data throughput. However, the advantage of these methods is that they can be easily implemented in hardware and are relatively simple to design. For the DPSK and M-ary PSK, adaptive channel equalizers may be implemented to overcome multipath propagation effects.

As an alternative to these modulation techniques, the pulse position modulation (PPM) method is also worth considering for underwater

acoustic data transmission, including voice, because of its suitability for power-efficient channels, comparative simplicity in implementation, and reduced sensitivity to multipath propagation. Digital information is transmitted by dividing each data frame duration (T_{symbol}), into "M" possible data slots, each of duration T_{slot}, and locating a transmission pulse in just one of these time slots.

To transmit quantized speech parameters, it is appropriate to select 8-slot DPPM, i.e. 3-bits per symbol. The symbol interval is subdivided into eight data slots and two guard slots. For this application, T_{symbol} = 1 millisecond, hence T_{slot} = 100 microseconds. For a speech frame interval of 22.5 milliseconds, the bit rate is defined by 1,000/22.5 (number of frames per second) x 18 (number of symbols per frame) x 3 (number of bits per symbol) = 2,400 bit/second. Moreover, the bandwidth efficiency of PPM, defined as R_b/B where R_b is the bit rate and B is the bandwidth, is favorable. With the receiving transducer bandwidth of 25 kHz, a bit rate of 4.7 kilobit/second for 8-slot DPPM can be achieved for through-water data transmission.

Since the envelope of the received signal may be used for data decoding, the binary ASK signal detection principle can be employed. Unlike for PSK, there is no extra processing for phase detection and unlike for FSK, there is no need for bandpass filtering. Hence, in terms of system complexity also, digital PPM is superior to the other techniques, although it has several shortcomings. Since signal transmission and detection is as in ASK, the technique is sensitive to multipath propagation. The destructive effects of multipath signal on the direct path signal can therefore cause an error in data decoding. In addition, accurate synchronization of the transmitter and receiver is required since both depend on accurate timing for pulse-position modulation and demodulation.

For a digital underwater voice communication system it is useful to set a frequency band so that transmission of digitized speech at a rate of approximately 16 kilobit/second may be achieved for a range of several hundred meters. Nowadays good communication quality speech is achievable for encoding techniques using bit rates of 8 kilobit/second or above and a frequency band over 150 kHz may be used if one of the low bit-rate speech coding standards such as VCELP, CELP, and LPC10 is implemented. Although this frequency band limits the communication range, it can still be beneficial for local area communications for the sake of speech quality. For our system, a 70 kHz transducer was chosen, since transmission of high quality speech at a data rate of 13 kilobit/second, i.e. RPE-LTP, can be accomplished although LPC10 at 2.4 kilobit/second is employed.

The advent of commercially available systems for through-water voice communications using digital techniques is long overdue. The prototype system built at Loughborough University, using linear-predictive coding and pulse-position modulation, has demonstrated that such systems are feasible and should be easy to design and implement using digital signal processors. The programmable flexibility that DSPs afford allow the future possibility of a variety of different encoding and decoding techniques to be used. These future advances in the use of presently available technology offer the possibility of clear, noise-free, high-quality voice communications for divers. */st/*

Dr. Hayri Sari, born in Samsun, Turkey, in 1965, received a bachelors degree in electronic engineering from Marmara University (Turkey) in 1988 and masters degree in electronic engineering from University of Manchester Institute of Science and Technology in 1992, and doctorate in underwater acoustic communications from Loughborough University in 1997. His research interests include underwater acoustic and optic communications, DSPs implementations into digital data transmission, and speech signal processing.

Professor Bryan Woodward has been at Loughborough University since 1975, where he has been department head and is presently professor of underwater acoustics. His main research interests are in underwater communications, telemetry and navigation, parametric sonar, correlation sonar, bioacoustics, and diver instrumentation—he has published over 100 papers on these topics. Woodward received his bachelor's of science, master's of science, and doctorate degrees in physics from the University of London in 1964, 1966, and 1968, respectively.

Monterey Bay Aquarium Research Institute

The Monterey Bay Aquarium Research Institute (MBARI) was founded in 1987 by David Packard with a mission "to achieve and maintain a position as a world center for advanced research and education in ocean science and technology, through the development of better instruments, systems, and methods for scientific research in the deep waters of the ocean." To carry out its mission the institute has defined six main goals:

- Identify important areas of marine science where research progress is limited by lack of appropriate technology
- Develop sophisticated systems for investigating aspects of the marine environment and its inhabitants where high scientific potential exists
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Management, Personnel, Facilities

Marcia K. McNutt serves as the institute's president and chief executive officer, managing a work force of approximately 170 scientists, engineers, and operations and administrative staff. MBARI scientists propose and execute innovative studies, both experimental and theoretical, in the ocean sciences. Engineers and operations staff, in partnership with the scientists, develop or adapt supporting technology.

MBARI's research ships *Point Lobos* and SWATH-designed *Western Flyer* and associated ROVs, berthed at the institute, have immediate access to Monterey Bay. MBARI also maintains moorings offshore, equipped with ocean-monitoring instruments, as well as two moorings in the equatorial Pacific that are part of the National Oceanic & Atmospheric Administration's Tropical Atmosphere Ocean (TAO) array.

Funding

As a private, non-profit research center, MBARI is funded by the Lucile and David Packard Foundation.

Deep-Sea Research

Monterey Bay is one of the most biologically diverse bodies of waters in the world, and the underlying submarine canyon—part of the complex geology of the continental plate margin—is one of the deepest underwater canyons along the continental United States. With a "laboratory" up to 4,000 meters deep only a few ship-hours from their base of operations, institute scientists conduct research relevant to much of Earth's water-covered realm.

A sampling of the multidisciplinary R&D projects currently underway includes: biogeochemical cycles, effects of El Niño in Central California offshore waters, gas hydrates and methane venting, oceanic distribution and cycling of greenhouse gases, deep-sea benthic ecology, cold seeps, marine bacteria and viruses, molecular probes for rapid detection of toxic phytoplankton, midwater biological communities, continental margin tectonics and subseafloor fluid flow, submarine volcanic processes, *in-situ* chemical analyzers and samplers, and real-time marine geographic information systems.

Another important task is the management and sharing of data collected by MBARI researchers, including more than 4,000 hours of videotape recorded by underwater cameras from the institute's ROVs. (Project summaries and other information about MBARI can be found at: http://www.mbari.org).

Historical Highlights

As of February 1998, R/V *Point Lobos* had carried out nearly 1,600 missions and its companion ROV "Ventana" about 1,400 dives. MBARI's new SWATH vessel, R/V *Western Flyer*, is optimized for ROV operations and capable of making extensive scientific voyages outside Monterey Bay. Its companion ROV "Tiburon" was designed and constructed in-house to perform a variety of science missions in depths as great as 4,000 meters.

MBARI scientists have conducted frequent measurements of seawater characteristics to compile an eight-year record of variability in coastal surface waters. They have also made extensive midwater surveys, which have resulted in the sighting of many new species and observations of unfamiliar animal behaviors. Institute researchers have investigated the ecology and geochemistry of Monterey Canyon's cold seeps and have devised methods and instruments for long-term, *in-situ* monitoring in the water column and at the seafloor.

MBARI collaborated in the IronEx expeditions (1993,1995), which demonstrated the link between phytoplankton productivity and the supply of iron in equatorial ocean waters. Institute geologists led the 1997 Monterey Bay Ocean Bottom International Seismic Experiment, making the first-ever ROV deployment of seismic instruments for long-period data recording.

MBARI will continue to build on its strengths, particularly in the areas of ROV design and operation and the development of instruments and systems for long-term, *in-situ* oceanographic monitoring. /st/

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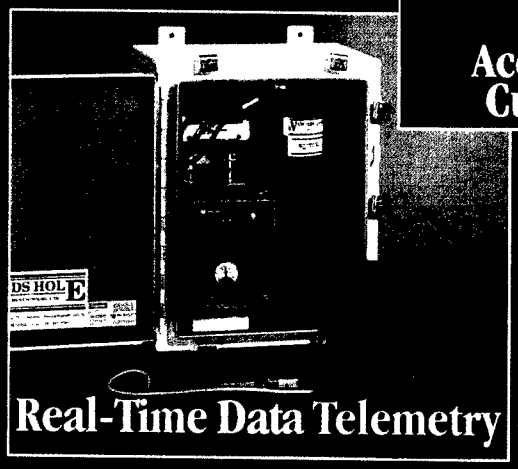

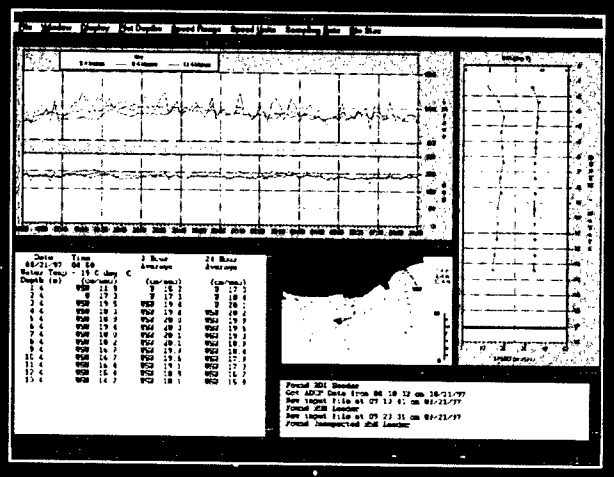

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Canadian Hydrographic Conference 98: A Significant International Event

"Canadian" may have appeared in the title, but the Canadian Hydrographic Conference 98 (CHC 98), held March 10-12 in Victoria, British Columbia, turned out to be a significant international gathering. Hosted by the Canadian Hydrographic Service (CHS), the Canadian Hydrographic Association, the Canadian Coast Guard, and the Canadian Institute of Geomatics, the conference attracted more than 600 delegates and more than 50 exhibitors from approximately 20 countries. Whether they came from next door—the United States—or the far end of the planet—New Zealand—delegates participated in three days of technical sessions having the theme of "Turning Data into Dollars."

When delegates weren't inside the perfectly suited Victoria Conference Centre, located on the Victoria waterfront, they could walk no more than a block to go aboard launches and two hydrographic ships from Canada and the United States. Within the conference center, the exhibit area doubled as the location for 12 poster sessions and all coffee breaks and lunches, thus guaranteeing traffic for exhibitors.

The conference began with a video presentation produced especially for the occasion, followed by customary welcoming addresses by dignitaries. The opening ceremony also featured a keynote address by Roy Henry Vickers, one of Canada's best-known aboriginal artists. In a humorous, yet spiritual, manner, Vickers reminded delegates of the long tradition that exists between his people and the coastal waters of British Columbia.

To be expected, the technical sessions covered all bases of the hydrographic world, from data gathering, to data interpretation, to data display. But it was much larger than that, for it also provided a forum for data users to show how information is power and how that power can lead to increased safety and reduced costs. For example, in the middle of a session dealing with ways that hydrographers have found for working with the private sector to reduce costs or improve service and efficiency, was a presentation by the harbor master for Nanaimo, British Columbia. He showed how having real-time tide information gave ship captains greater confidence in being able to use the harbor and saved considerable sums that might otherwise have been spent on dredging.

Several papers featured approaches used by government agencies to continue delivering hydrographic services despite budget cutbacks. For example, CHS has had good success turning over the marketing and distribution of maps to the private sector. Meanwhile, the U.S. Army Corps of Engineers reports that its long-standing practice of contracting hydrographic services to the private sector has been so successful and cost effective it will be expanded.

On-the Fly GPS

As examples of new services, the provision of on-the-fly GPS service in real time is being used to supplant tidal gauges and tidestaffs along one section of the St. Lawrence River while navigation, dredging operations, and hydrographic surveys are being aided in the United States by differential global positioning system (DGPS) stations being installed by the Corps of Engineers. In both instances, these new services will aid mariners and reduce costs.

The multibeam echosounder (MBES) is becoming more widely used every year. In fact, CHC 98 was preceded by the fifth annual US-Canada Hydrographic Commission shallow-water multibeam course, which lasted nine days. During the conference itself, speakers reported U.S., Canadian, French, and German experiences with MBES and MBES data processing, information that will no doubt be analyzed carefully by specialists in this field. While one of the challenges will be to develop or improve software that is capable of routinely processing up to 3,000 data points per second from MBES systems, experience also shows that a wider variety of transducers is needed for specific survey situations.

Advances in the digital world are continuing to affect the way hydrographic information is made available to mariners. The expanding use of multibeam echosounders is generating huge volumes of data that must be digested and then passed on to mariners. Clearly, the transition between conventional paper charts and electronic charts is well underway, but chart makers, like their pinging echosounders, are still feeling their way.

Meeting the requirements for electronic navigation charts that comply with International Hydrographic Organization (IHO) standards was the subject of several papers, with special focus on explaining and clarifying terms and relating these requirements to the rapid development of ECDIS (electronic chart display information systems). Other ECDIS issues dis-

cussed at the conference included the need for good ergonomic designs for shipboard displays and the standards that must apply to electronic chart databases. ECDIS is even putting pressure on hydrographic offices to provide venerable tide tables in digital form. While ECDIS is an expensive investment, the Canadian Coast Guard reported that the economic payback for ECDIS equipment on its ships was approximately 12 months, owing largely to fuel savings, time savings, and reduced engine movement.

"Several papers featured approaches used by government agencies to continue delivering hydrographic services despite budget cutbacks. For example, CHS has had good success turning over the marketing and distribution of maps to the private sector."

Data storage and processing is a vital activity in all hydrographic offices. At CHC 98, some of the more esoteric aspects of data management were discussed, along with the quality-control aspects that result in reliable charts and information. Papers in these sessions ranged from a discussion of the geodetic reference systems used in Canada and the United States to presentations on new data services or new ways of providing familiar data.

Since there is no point in gathering bottom information if you don't know where you are, several papers were presented on GPS. In addition, two workshops on GPS were held the day before CHC 98 began. While one workshop was fairly elementary, the second covered GPS and augmented GPS for hydrography and marine navigation. Among the various developments reported at the conference was the Canadian Coast Guard's program for installing a differential GPS network that will provide coverage to most southern Canada waters.

Indirect Measurements

While considerable focus was placed on making sense of signals returned from the seafloor, several presentations discussed the relationships between the results obtained from indirect measurement methods to those gathered by ground-truthing techniques. This was particularly evident in sessions relating to management of the coastal zone, marine habitat management, and seafloor classification. GPS-based airborne videography, underwater videography, and side-scan and depth sonars were discussed. Regarding the use of echosounders, it was shown that as more experience is gained and as technologies improve, better correlations can be made between returned echosounder signals and ground-truth information. In particular, several speakers claimed the RoxAnn system (Marine Micro Systems Ltd., Aberdeen, Scotland) has been used with fairly good success in mapping benthic biological communities and classifying bottom sediments in the Great Lakes and the St. Lawrence River.

Post-conference tours of the Canadian Coast Guard station in Victoria and the Institute of Ocean Sciences in nearby Sidney brought the event to a close. Everyone was reminded to make room on their calendars next April for U.S. Hydrographic Conference 99 in Mobile, Alabama, and CHC 2000 the following year, which will be held in Montreal. */st/*

Future Prospects for Ocean Engineering Education

By Dr. Stanley Dunn
Chairman, Ocean Engineering Department
Florida Atlantic University
Boca Raton, Florida

"There is perhaps no other engineering discipline more explicitly and obviously involved with its practice environment than ocean engineering. Here the challenge to ocean engineering education lies in integrating the non-technical with the socio-economic aspects of these difficult issues."

After some 35 years since the first ocean engineering educational programs were introduced, the present picture is one of both stability and the promise for future growth. Students motivated to build engineer careers associated with the ocean continue to arrive at the nation's universities seeking opportunities to study in their chosen filed of interest. These students tend to be focused in their interests and see the ocean as presenting a unique and challenging environment.

As a result, today seven university programs at the bachelor's level and two at the master's level offer ABET accredited degrees in ocean engineering while many other engineering programs offer opportunities for students to focus in ocean related areas. While clearly not so numerous as the more familiar degrees in mechanical, electrical, civil, or computer engineering, these efforts nonetheless continue to sustain themselves by the recurring demand of students who want the ocean engineering education experience and the broad community that receives them upon graduation.

As with any market, ocean engineering has seen its ups and downs since the time of the wildly optimistic 1960s. Today, the nation is once again recognizing through the National Oceanographic Partnership Act of 1996 the importance of the ocean. The act also points the way in terms of what is expected of ocean-related academic programs if they are to effectively contribute to the process of understanding and developing technology for the ocean. Strength in the classical elements of ocean science and engineering must be enhanced by the innovative employment of emerging technologies and the judicious use of collaboration to achieve the most cost effective approaches possible.

Profession's Future Bodes Well

With Oceanology International 98 (just last month in Brighton, England) having its largest program ever, even with an appropriately skeptical perspective, the evidence from the marketplace bodes well for the profession. In terms of defense, the task of building future generations of dramatically more cost-effective ship and other naval systems presents challenges sufficient to excite any potential ocean engineering student. The press of an increasing world population seeking better standards of living continues to stress the world's ocean resources. To effectively manage this complex problem, not only will we need to develop more efficient ways of recovering the ocean's resources, we must do so in a much more environmentally sustainable manner and usually at lower costs.

There is perhaps no other engineering discipline more explicitly and obviously involved with its practice environment than ocean engineering. Here the challenge to ocean engineering education lies in integrating the non-technical with the socio-economic aspects of these difficult issues.

Thus, ocean engineering programs must continue to school their graduates in the fundamentals that have been proven over time to be essential elements for practicing engineering in the ocean. In addition, academics must ensure that their students are integrated into the mainstream of new science and technology waves and recognize computing as not only a computational tool but as an essential element in communications, systems control, and teaching. We must recognize that ocean engineering needs to seek technologies from other non-marine areas for adaptation if cost-effective solutions are to be possible. Finally, ocean engineering graduates must be both functional in the engineering tools of today, if they are to get that first position, yet equally able to think adaptively in order to assure a long career.

In many regards, there is much that is familiar about these requirements. However, today's rapid pace of expansion of both ocean problems and ocean technology areas such as materials, intelligent control, simulation, communications, and computational mechanics is dramatically increasing the domain in which ocean engineers must be. The increasing depths at which offshore oil recovery is now carried out is requiring better understanding of material properties if long exposure, high reliable subsea systems can be developed and fielded. Com-

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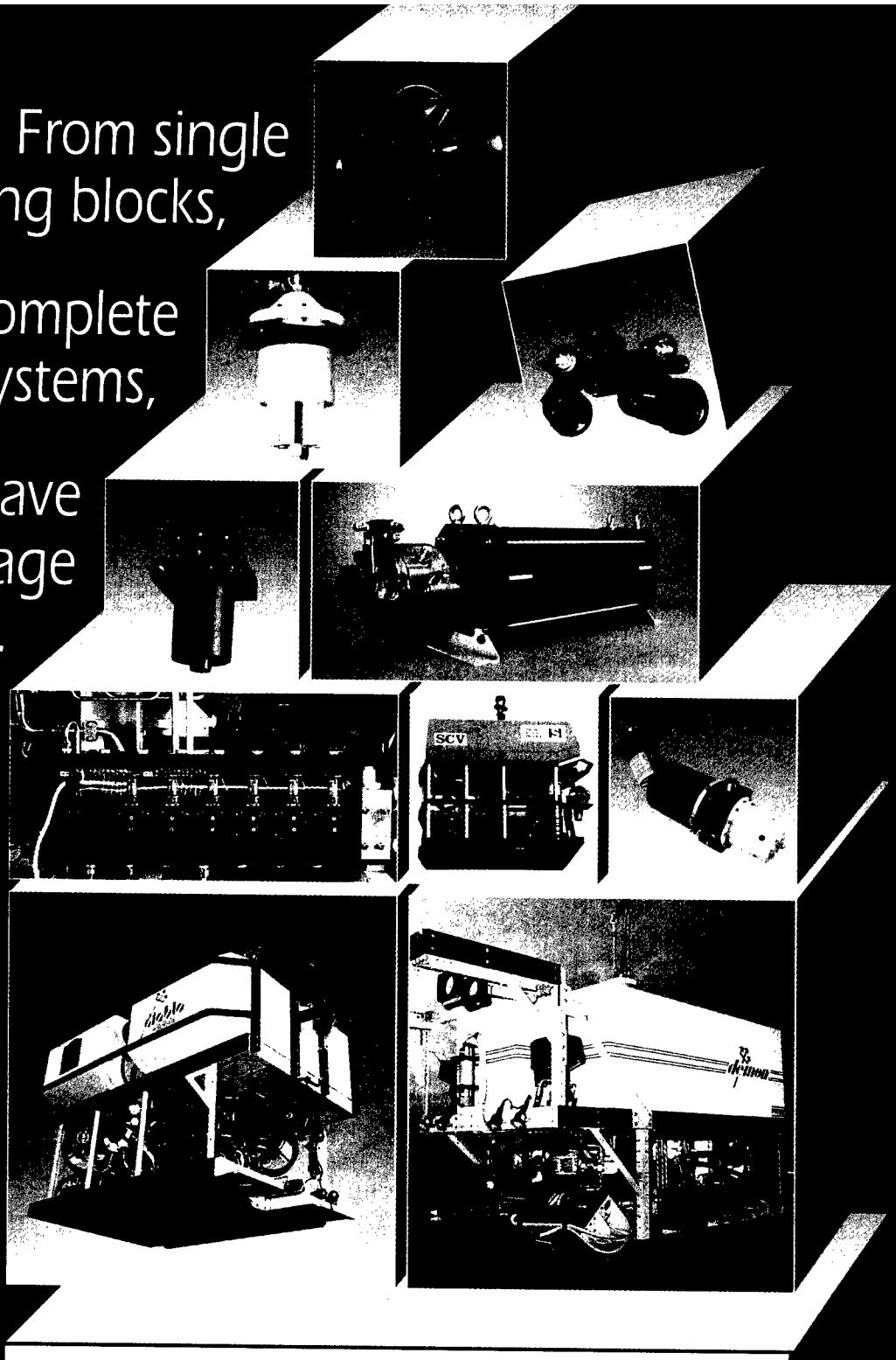

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"Clearly, those of us in academia can view the future with enthusiasm. The field of ocean engineering is entering new and exciting times. Opportunities are emerging to strengthen the ocean engineering process, beginning with how we attract students and finally to the manner in which they transition into the professions."

puter-aided full-feature simulation and design are key to achieving cost-effective ship designs in our nation's shipbuilding industry.

In an another area, the economy as a whole is being swept by a technology wave of distributed computing and communication. These technologies come from non-marine sectors of the economy where huge commercial investments rapidly advance the art. These fundamental technologies are key to the development of systems to access oceanographic information that is so vital to understanding our global environment. They are fundamental to next-generation Navy ship systems where greater capabilities must be provided at reduced life cycle costs.

Challenging Introductions

The manner in which ocean engineering education introduces these many new critical technologies to their curriculums is indeed a challenge, matched only by the cost of doing so.

Ocean engineering shares the challenge common to all engineering disciplines as it attempts to educate its students in an increasing number of critically important subjects—yet not lose sight of these critical elements that have been the foundation of the discipline. It must do this at a time when the preparation of its incoming students is not always what it might be, both in terms of academic training and the appreciation on the part of the student as to the dedication that is required to master difficult subjects. At the output end of the process, it is equally necessary to examine the manner in which the academic programs prepare the student to smoothly transition into the profession. This is where industry must play its role through working partnerships with academia in shaping the final stages of a student's academic career. This is an area that requires much more attention.

Clearly, those of us in academia can

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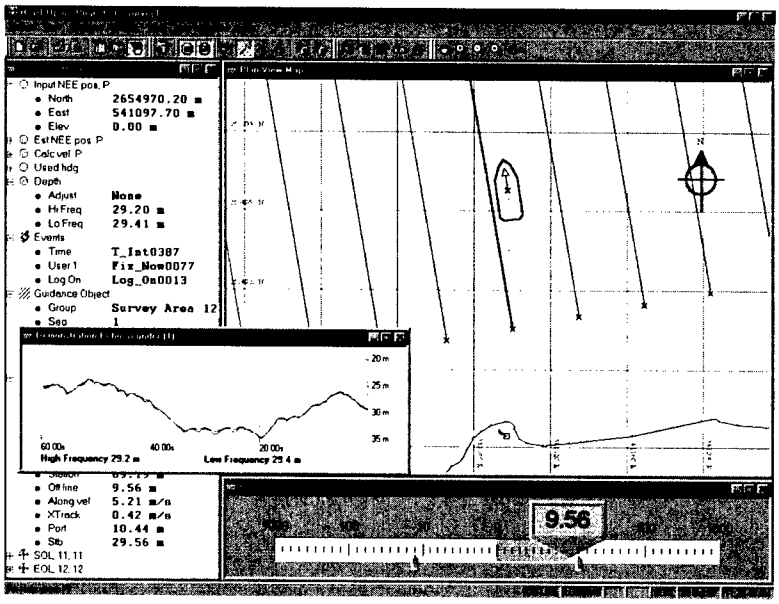

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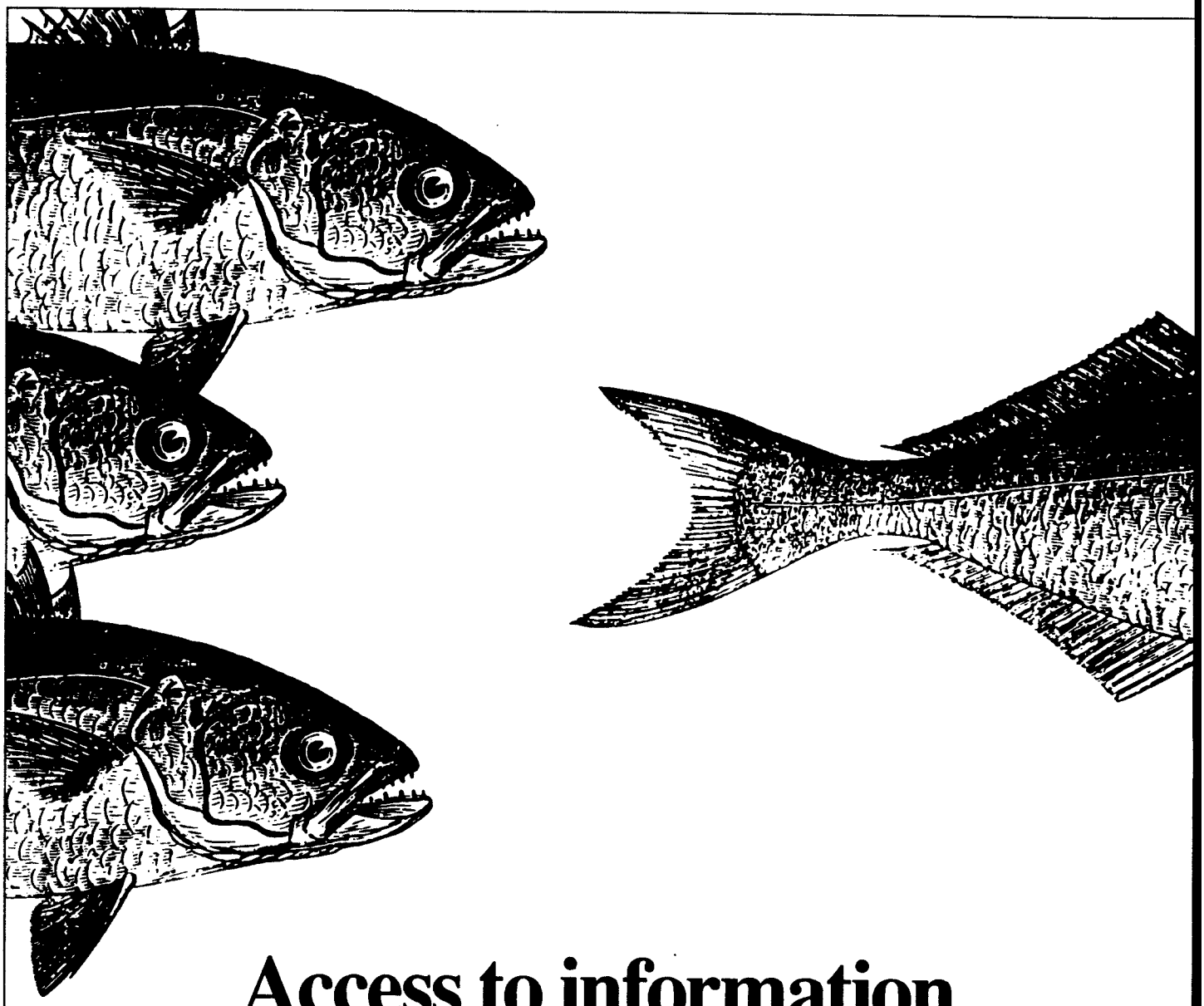
view the future with enthusiasm. The field of ocean engineering is entering new and exciting times. Opportunities are emerging to strengthen the ocean engineering process, beginning with how we attract students and finally to the manner in which they transition into the professions.

This news is surely making its way to the youth of our nation. Our experience suggests that student interest continues to be high, especially when they can see opportunities to participate in innovate programs that exhibit a real ocean character to them. If the Human Powered Submarine competitions are any lesson, student interest clearly remains strong. The market for ocean engneering graduates remains strong, including areas not directly related to the ocean. The challenge to ocean engineering academia is to respond to the advancing technology opportunities in order to continuously invigorate their curriculums. Further, forming partnerships for the purpose of both developing the support for their programs as well as defining the character necessary for the future is now essential. Viewed from any perspective, this is a time when there are strong waves to ride and the future in ocean engineering education is exciting. */st/*

Dr. Stanley E. Dunn graduated from North Carolina State University in 1965 and completed his doctorate there in 1970, specializing in acoustics and vibration. He has been a professor at Florida Atlantic University since 1971 and chairman of its Department of Ocean Engineering since 1983. Dunn started a program in 1987 for development of UUVs, collaborating with Carnegie Mellon University, Massachusetts Institute of Technology, and Martin Marietta through Perry Offshore Inc. He is currently involved in a variety of research projects funded by several agencies such as the U.S. Navy, the Department of Transportation, and NSF.



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PACON 98: An Innovative Ocean Congress

Under the principal sponsorship of the Korea Ocean Research & Development Institute, PACON 98 (the Pacific Congress on Marine Science & Technology) will take place June 15-19 in Seoul, Korea, in conjunction with 19 other sponsoring agencies and societies. The meeting will focus on coming marine trends and issues in the Pacific. Major theme of the meeting is "Towards the 21st Century: The Pacific Era."

PACON is a network. It began in 1982 under the inspiration of University of Hawaii professor of engineering, Dr. Narendra Saxena. In the Pacific Rim, there are large numbers of highly creative people coming up with new and potentially world shifting ideas. The idea of PACON was to bring the most innovative people in the area of marine industry, government, and the academic community together to share new ocean concepts and technologies. ocused conferences in alternate years.

The first PACON conference began in Honolulu in 1984 with more than 250 participants. Each conference since then has grown. PACON 90 was in Japan with 350 participants from 22 countries. PACON 94 in Australia drew 400 participants from 27 countries. PACON 96 returned to Honolulu with more than 450 participants. The regional symposia began with PACON 93 in Beijing, followed by PACON 95 in Honolulu and Hong Kong's PACON 97. A very exciting conference, PACON 99 is presently being developed for Moscow. Attendance at PACON 98 is anticipated to be 500.

Economic Engine of the Future

PACON has recognized that the economic engine of the future is in the Asian-Pacific Rim. PACON and its international board of directors have established close contact with leaders in this area and have acquainted them with what the oceans have to offer. This is seen as the first step toward developing new marine opportunities and solving the issues they raise. New industries do not come primarily from Internet inquiries or advertisements but from persistent personal contact and service. This is what PACON does and how it can help its members and conference participants.

PACON 98 is a major conference focused in the area of new ocean developments and techniques as well as environmental issues. It will feature 34 separate topical sessions geared to these developments and opportunities. Included in these are such things as marine instrumentation and technology, mapping and global observing systems, advanced ships, marine biotechnology, sustainable development programs, marine ranching, fisheries, mariculture, ecotourism, coastal oceanography, and land reclamation among many others. Key features of PACON conferences are general lectures. There will be four at PACON 98. The first of these is on progress in ocean science in India by the Delhi Institute of Technology's Dr. Qasim. The second will look at bottom features in the Yellow Sea by Professor Ying Wang, dean of the School of Geoscience of Nanjing University. The third general lecture by Dr. Park of the International Tribunal of the Law of the Sea will consider LOS issues. The final general lecture by Dr. Huntley, president of Aquasearch, will look at the bright future of marine biotechnology. The keynote address will be presented by Dr. Alfred Beeton, NOAA chief scientist and advisor to Dr. Jim Baker, undersecretary of commerce for oceans & atmosphere in the United States.

Korea: Exquisite Timing?

Perhaps the most significant thing about PACON 98 is the location and timing of the conference. This major conference will highlight the new importance that Korea is placing on the ocean as it moves into the 21st century. This importance cannot be overemphasized. Large-scale offshore oil developments are planned; massive mariculture developments are found off many of the coasts of Korea with more to come.

PACON 98 will begin with registration on Sunday night, June 14th. The opening ceremonies will take place the morning of June 15th, followed by the 34 technical sessions over the next four and a half days. The meeting will conclude on Friday, June 19th. It will take place in excellent conference facilities at the Sheraton Walker Hill Hotel in Seoul. There is ample room for exhibits. Registration charge is $470 per delegate. The exhibit booths are $1,500. All arrangements to attend, exhibit, present material, get reduced rate accommodation, or join the PACON network can be made through the PACON International Office at (808) 956-6163, fax (808) 956-2580, email: pacon@wiliki.eng.hawaii.edu.

PACON 98 can serve as a gateway for your participation in future ocean development in Asia.—**Dr. John Wiltshire,** *associate director, Hawaii Undersea Research Laboratory, University of Hawaii.*

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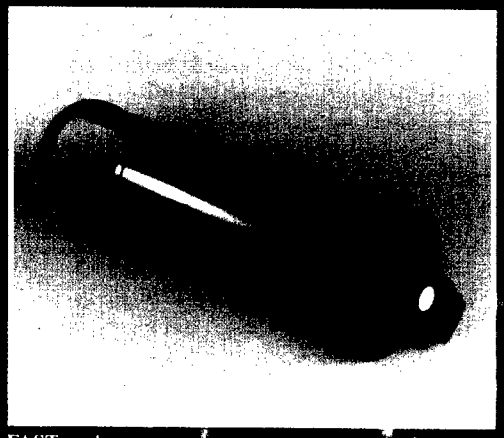

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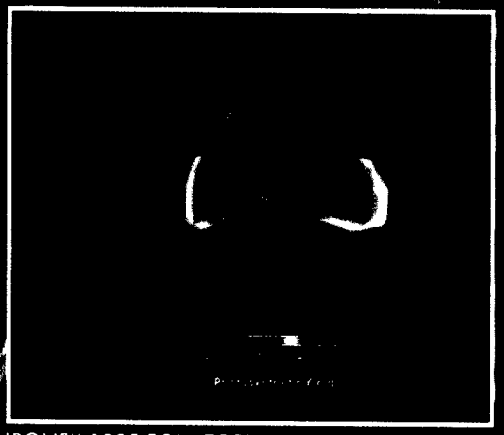

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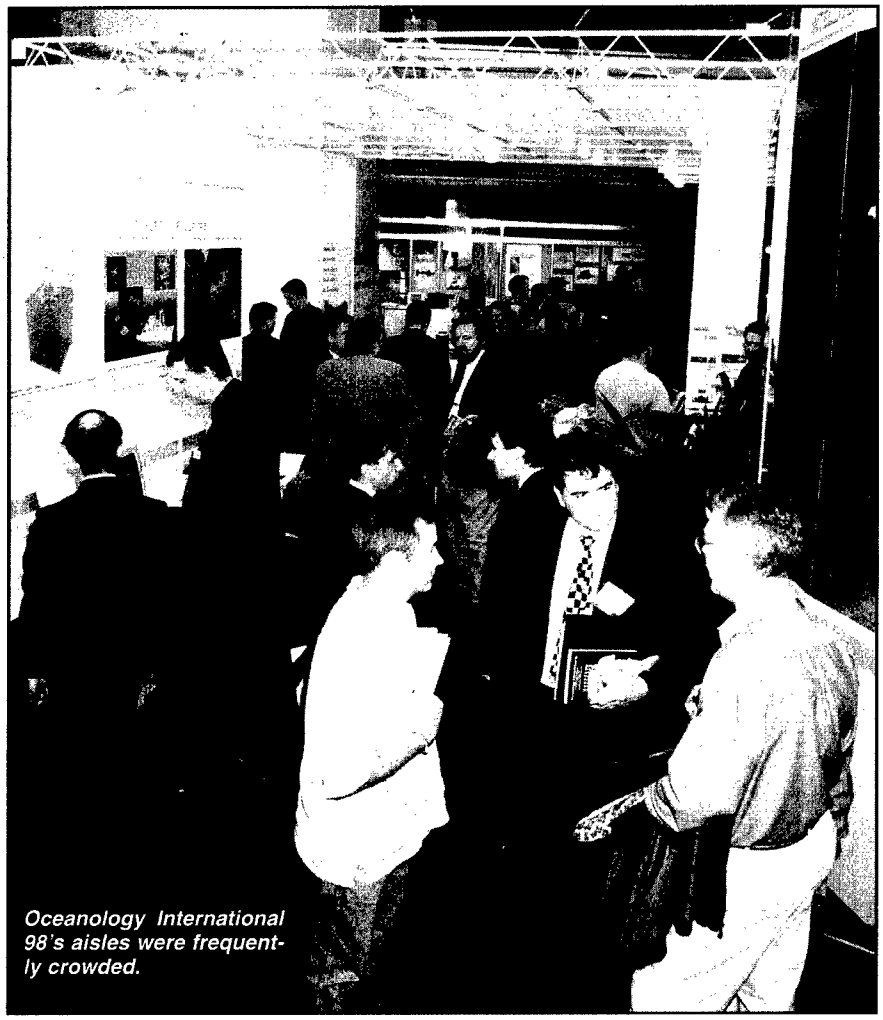
Oceanology International 1998: A Record-Breaker in Brighton

A 'Mirror of the Current Mini-Boom,' OI 98 Drew 6,033 Attendees & Exhibitors; Featured 550+ Exhibiting Companies, 125 Technical Papers

By David M. Graham
Editor

When all the dust had settled, artwork stripped from booth walls, computers and current meters and ROVs all boxed up for shipment, Oceanology International 98 proved a mirror of the mini-boom that seems to be happening now in the international ocean business community. Ms. Versha Carter, project director for OI 98 from organizer Spearhead Exhibitions Ltd., first noted that the counters hit 5,523 for regular attendees and exhibitors. Another 375 university students from around the United Kingdom swelled the final count to 5,898. If that weren't good news enough, she noted that a missing ticket-stub box boosted the final count to 6033. "It was by far the busiest OI ever," she stated.



Oceanology International 98's aisles were frequently crowded.

Over the course of the conference, attendees will be treated to an array of products and services from more than 550 exhibitors and 125 papers in the technical sessions.

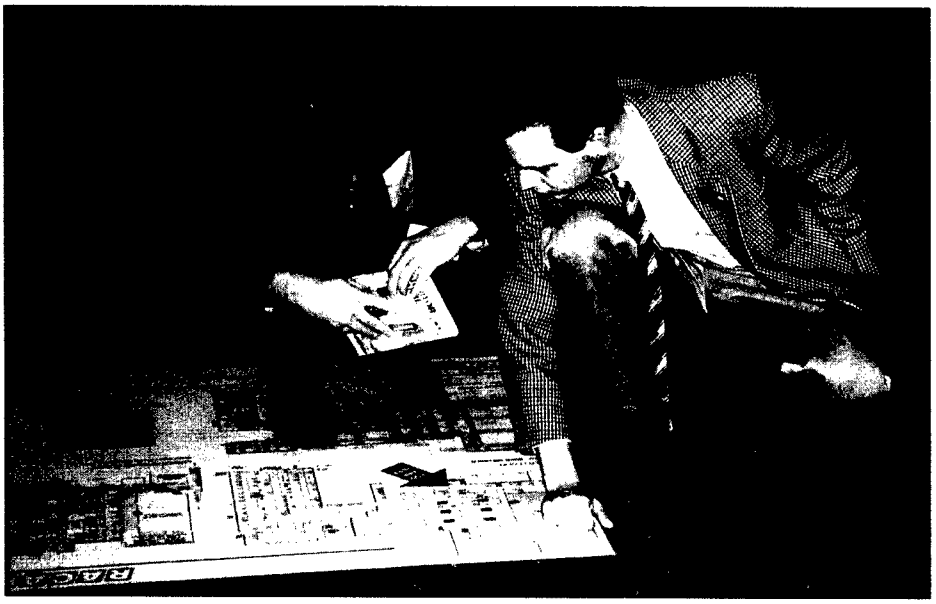
Human Impacts Have Changed

During the International Year of the Ocean, when we are focusing especially on the protection of our common marine environment, Rt. Hon. Michael Meacher highlighted how human impact on the marine environment has changed over the centuries. "But the current century has seen by far the most rapid and extensive changes of all," he added. "In 1994-95, marine related activities contributed £27.8 billion to the U.K. economy alone, nearly 5 percent of gross domestic product. The offshore oil and gas industry makes up the largest proportion of this figure, with shipping, fisheries, defence, and leisure activities also making significant contributions."

Meacher is U.K. Minister for the Environment. He cautioned that, in the past, we in the developed world have been perhaps the most persistent offenders in this matter.

The biennial conference-considered the premier ocean exhibition any—where—was held as usual in Brighton, a "seaside" resort town an hour's train ride south of London, on March 10-13 in the Metropole Hotel & Conference Centre.

This year's meeting broke the 1996 record attendance by 1,274 souls—a 27 percent boost. Judging by the welter of positive comments and rave



Racal's brilliant move put much-appreciated exhibit hall maps underfoot everywhere.

reviews from exhibitors and attendees alike, OI 98 also broke records for kudos. Nary a contrary word was heard.

Dr. Gwyn Griffiths, conference committee chair and head of Southampton Oceanography Centre's Ocean Technology Division, said, "this conference has exceeded all expectations in terms of turnout and interest. We most definitely hit the right topics; people who have never been before assure me they will be returning in two years' time."

Carter told *Sea Technology* that most of the attendees naturally came from Britain; the United States was second with 322. She added that the highest figure (1,668 attendees or 29.5 percent of total) listed their job descriptions as "research and development." Nearly the same number (1,174 or 20.7 percent) described themselves as "senior management."

Another frequent visitor, Dr. Don Walsh, observed that in one new development in the exhibit halls, nearly a half dozen companies rolled out large work-class ROVs. Costing upwards of $1 million each, fully equipped, several are capable of diving to 3,000 meters. "Work class ROVs had in the past been offered by only a very few companies with the American company Perry Offshore having a near-monopoly for this type of submersible," he said. Several new companies in the field could augur more competition for price and performance in deep-ocean work tasks.

In addition to ROVs, Walsh noted, this year's show also featured two autonomous untethered vehicles. One of them from Marconi has been seen previously; it was joined by a new AUV—Hugin—from Norway's Kongsberg Simrad. "Both vehicles are operational and are perhaps precursors to a

new capability in deep ocean operations."

Remote Sensing: Coming of Age

Remote sensing of the oceans by way of earth-orbiting satellites has been exhibited at Brighton for the past several years. This year it was clear that satellite remote sensing is fully operational and that the number of companies offering these services is significantly increasing. Products shown at OI 98 were less pretty pictures of our planet but more the economically employable imagery usable by commercial customers. Walsh noted that ocean remote sensing has also matured into a multifaceted service business and this was very evident at Brighton. "As with remote sensing from space, the fine-grain mapping of the seafloor using ship-mounted, multibeam acoustic systems has expanded rapidly from a few service companies to many who offer commercially orientated survey products." Also evident were the increasing numbers of companies who now offer the basic multibeam systems.

Walsh also told us he was seeking yet another personal world record. Co-holder with Swiss oceanographer Dr. Jacques Piccard of the record deep dive (nearly seven miles down in the Marianas Trench) which can never be bettered—only equaled—Walsh said he plans to visit the site of the actual North Pole under the arctic ice. "Countless vessels have passed over the site on the ice and more submarines have cruised nearby under the ice—but nobody has reported seeing the seafloor where the pole resides," he said. Walsh will view and photograph the small pole (if it exists) at the site in 1999 through the ports of one of Russia's *Mir* submersibles.

'On the Floor' Transactions

Adding to the general frenzy of good spirits on the exhibit hall floors, the level of "business as usual" was encouraging. The amount of business conducted or announced at Oceanology is a distinguishing feature. A good many companies use the Oceanology venue to launch major "deals" and/or announce new products. Following is but an example:

AlliedSignal ELAC GmbH said it had been awarded a contract for the "first-ever, dual-frequency multibeam echosounder Bottomchart." The system was ordered just prior to OI98 and was to be delivered to the Second Institute of Oceanography Hangzhou in China last month.

All Oceans Engineering Ltd. and Hydrovision Ltd. penned an exclusive agreement to provide work-class tether management systems to the global ROV market. The agreement provides Hydrovision with worldwide exclusive rights to the sales of the All Oceans 750-series subsea winches for use on their new long excursion, heavy lift Tether Management Systems. The partnership has already generated its first sales for a garage' and a top hat' system with delivery of the first system expected by the end of March. They are destined for deep water operations in Brazil with Hydrovision's 100 HP Demon ROV systems operated by DSND Consub.

Ashtead Technology said they have purchased an additional $250,000 of Trimble Navigation Ltd. global positioning system (GPS) equipment. This is in addition to the $120,000 worth of equipment purchased over the last 12 months to satisfy customer requirements. The equipment includes the lat-

U.K. Environment Minister Michael Meacher poses a question to Richard Burt of Chelsea Instruments Ltd. as Ellen Keegan looks on.

est versions of the 4000ssi, 4000RS, 4000DS, DMS PRO, PRO XR, NAV Beacon, and software. Ashtead is at the moment placing orders for model 4800 and 4400 units.

GEC-Marconi Underwater Systems Group at Waterlooville has been awarded a multi-million pound contract by the Defence Evaluation & Research Agency (DERA) to develop and build an unmanned underwater vehicle (UUV) for technology evaluation. The contract will provide DERA with a vehicle to evaluate the feasibility of deploying UUVs in reconnaissance operations for future Royal Navy requirements. The UUV design will draw heavily upon the company's torpedo technologies and seven years of UUV research that was initiated in 1991 with the DTI through the "Wealth from the Oceans Initiative." The project will advance technology in several important areas such as fiber optic telemetry, precision navigation, and autonomous control. The GEC-Marconi vehicle will commence sea trials in early 2000 and will be delivered to DERA at the beginning of the following year. DERA will be responsible for conducting the proof of concept trials program. In addition to its military operations, DERA and GEC-Marconi will be working together to explore the application of the evolving UUV technologies to the civil offshore surveillance market.

Fugro GEOS and RD Instruments (San Diego, California) announced a collaborative agreement that allows the two companies jointly to develop the growing market for deep water environmental data acquisition and forecasting.

The Central Marine Geological & Geophysical Expedition (CGGE) of Gelendzhik, Russia, has been re-united with the other division of the former Yuzhmorgeologiya Association to form the State Geological Enterprise "Yuzhmorgeologiya." Former Prime Minister Chernomirdin of the Russian Federation awarded SGE Yuzhmorgeologiya the status of State Scientific Center of the Russian Federation. As the new national marine center of Russia, SGE Yuzhmorgeologiya will receive priority financing and be responsible for geological, geophysical, and oceanographic exploration; contracting internationally for world-ocean exploration; implementing national programs for scientific research; training highly qualified scientific personnel; development and

implementation of forecasts and estimates of mineral resources; development, design, and manufacture of new systems for exploration and mining software development and digital modeling; and establishment of standards and certificates of marine technologies.

Bargain Research Vessel Leases

A spokeswoman said SGE Yuzhmorgeologiya will continue to offer its several research ships and state-of-the art research equipment and survey systems for survey and research internationally through CGGE International, operating out of Redmond, Washington (USA).

GeoAcoustics Ltd. received an order from Racal Survey Ltd. for a deep water combined GeoChirp/side-scan system. Racal was said to be quick to recognize the quality and versatility of this system. This order valued at over £100,000 brings to six the total number of combined systems supplied to Racal in the last 12 months. The previous systems have been deployed with Racal in Malaysia, Egypt, and with its Near East and North Africa operations. This latest system will be mobilized on board Racal's latest vessel to enter North Sea service, the *Racal Northern* (*Mansal 19*) and will be used primarily in general construction support surveys.

Scantron Ltd. reported it purchased four Isis sonar data acquisition and processing systems for its lease pool. The Isis sonar system will serve as the primary data acquisition and processing package for Scantron's range of digital side-scan and swath bathymetry sonar systems and is now available for lease through several companies worldwide.

For OI, this was very much the "bigger year of the launch" with new product introductions galore throughout the show. A conservative estimate preshow put the number at around 130.

Launches range from the new Sea Serpent ROV on the Racal Survey stand to the new release of Falmouth Scientific's new Windows 95/NT acquisition, configuration, and post-processing software for all FSI CTD instruments. The company was offering a free demo disk on the Falmouth stand. In addition, other introductions included the new Stealth ROV from Seateam, the Plus version of SeaPro 2000 available from Euronav Navigation, the first of a series of acoustic relocation pinger products (the MCP-375) from Billings Industries, and the Ceetide tide gauge and Ceesure (marine pilot system) from Bruttour International Pty.

SubServ Ltd. made its debut at OI 98 with a competence assurance scheme that is already accepted by major ROV contractors and associated industries.

On Thursday, MacArtney A/S UK announced the award on the first day of the show of a major slip-ring contract from SubSea Offshore. The contract calls for the supply of 16 Focal Technologies electro-optic slip-ring units to be incorporated into a new build program of SSO deep water work class ROV systems. The units, to be used in surface lift winches and tether management systems, carry high power, signal, and multiple optical passes in a single unit. The order, valued at Dkk 2 million, is scheduled for a phased delivery over the next six months.

Fugro Group reported it had bought the long-range survey vessel *Jean Charcot.* The 74-meter-long vessel

will be mainly employed on deep water route surveys for fiber-optic communications cables. *Jean Charcot* has 30 berths for survey personnel, enabling full offshore processing to be carried out. She is equipped with Simrad EM12 and EM1000 echosounders and a 12-kHz sub-bottom profiler.

TSS, SAIC Pen Joint Contract

TSS (UK) Ltd. and Applanix of Canada announced the award of a joint development contract with Science Applications International Corp. (SAIC). TSS and Applanix will jointly design the POS-SV, a novel, highly accurate underwater navigation system. SAIC is supporting development of the system, the first of which will be integrated with the high resolution sensors on its Focus 1500 ROTV to provide high performance position/heading and attitude data. Provisional design aims include a factor of 10 improvement over standard USBL positional performance.

DERA purchased an Aquashuttle Mk III towed oceanographic vehicle from Chelsea Instruments Ltd. and have upgraded its previously acquired SeaSoar vehicle system (also by Chelsea) with the purchase of a new improved deck unit. Chelsea officials also announced the appointment of Environmental Sensors Inc. as its exclusive representative in Canada and the USA. ESI will provide Chelsea with full sales, service, and calibration facilities. Ivy Iverson, Chelsea Instrument's U.S. representative for many years, has joined ESI and will continue to support Chelsea in his new role.

The revolutionary new nutrient and chemical monitoring system launched by Chelsea also created great interest. It applies universally accepted flow analysis techniques in a field instrument.

Nopec International ASA of Norway confirmed the order for the second 2-D seismic afterdeck machinery package with Marine Project Development Ltd. The equipment is to be fitted to the R/V *Northern Access* and the R/V *Southern Access* in Holland. This second order completes a substantial two-vessel afterdeck package for delivery in 12 weeks.

Falmouth Scientific Inc. said it had been awarded contracts for five 3-D WAVE units for Brazil and two for New Zealand—both for delivery this year. FSI also launched its new wave height and director, 3-D wave current meter at OI 98. The 3-D WAVE combines the high-performance acoustic current meter with a state-of-the-art micro-machined silicon pressure sensor. This enables the user to perform wave direction and spectrum analysis as well as tide and wave height measurements with a single instrument. The unit comes complete with Windows 95/NT 3DACM97 software for configuration and real-time graphics.

DigiCOURSE Inc. selected Applied Microsystems Ltd. to provide a time-of-flight direct sound velocity measuring sensor for the former's new model 7000 streamer-mounted velocimeter. This is the first product that has incorporated this technology in a streamer-mounted device. The model 7000 is designed to be mounted on a seismic streamer to provide accurate real-time velocity measurements to improve range accuracies in the complex acoustic networks that are becoming more common in marine seismic acquisition. This large blanket order for an undisclosed quantity of sensors was placed on the opening day of OI. DigiCOURSE anticipates a significant demand for this product. Applied Microsystems is providing these sensors exclusively to DigiCOURSE for

this application.

Seateam representatives announced a frame agreement with Ashtead Technology. This worldwide agreement encompasses the supply of state-of-the-art survey sensors, ensuring Seateam continues to provide the industry with a world class operational performance.

Stolt Comex Seaway in Bergen, Norway, added three more Triton Elics International Inc. Isis sonar systems to its existing line. A Stolt spokesman said the firm selected TEI as its standard sonar and seismic data acquisition system source because of the system's powerful capabilities, large number of interfaces, and ease of use. Capabilities of the system include acquisition, display, and processing of up to eight channels of sonar and seismic data simultaneously; automatic pipeline tracking and freespan detection; real-time coverage mapping; and digital side-scan sonar mosaicking.

TSS Ltd. also revealed the major sale of a package of equipment including motion sensors, inertial navigation systems, pipe trackers, and two of the latest Deeptrack systems (released at OI 98) to Ashtead Technology of Aberdeen. The total package (valued at in excess of £600,000) includes five DMS-05 dynamic motion sensors, two POS-MV inertial navigation systems, two Deeptrack pipe and cable tracking systems, and one 340 pipe tracker.

Sonar Winch Order

Valeport Ltd. reported receiving an order for a further 10 sonar winches for C-Max Ltd. When the latter introduced the CM800 side-scan sonar system, officials asked Valeport to design a winch to handle the sonar's unique ultra-slim fiber-optic tow cable. Over the last four years, this cable option has been chosen by more than half the CM800's purchasers and all of these installations use the Valeport winch. The winch is also available directly from Valeport as the SK172 portable oceanographic winch.

Seatronics placed an order with Valeport for a model 308 self-recording current meter. This purchase brings Seatronics orders placed with Valeport for in excess of £90,000 since the beginning of the year. Seatronics have offered Valeport's oceanographic products from its rental pool since 1992. In addition to the popular model 604 deep water CTD, Seatronics took Valeport's model 105, model 108 Mk III, and model 308 current meters.

Company president Charles Quartley said he has recruited two temporary sales assistants to help maintain the "no-more-than-one-in-front" guarantee. "Checkout queues at Valeport Retail Ltd. (at OI98) were restored to normal following a surge in demand for products straight from the shelf," he said. Valeport was amazed at the level of demand for products directly from the stand; officials were fairly confident they would not be carrying much home to Dartmouth.

Spearhead's Carter said interest was already at "fever pitch" for Oceanology International 2000, slated again for March 7-10. There appeared to be a general sigh of relief when show officials announced that Brighton would remain the venue of choice for this traditional show. Advance hotel reservations and "bed & breakfast shopping" activities seemed to be brisker than usual. It could be cryptic, however, that handsome sweatshirts touting OI 2000 Spearhead handed out to exhibitors did not indicate *where* the next conference would appear. */st/*

Shoelaces to Software—A Virtual Tour d'France

Wervicq Sud, France—Ahhh, Wervicq in the....winter? Sunlight was just as bright in this northeastern city where 150-year-old rope-maker **Cousin Trestec S.A.** holds forth. The factory was stop No. 1 on a whirlwind tour of French companies headed for Oceanology International 98 in Brighton.

In the quaint brick buildings where the back doors open into Belgium, engineers and workers turn out high-tenacity aramid ropes, cables, and almost anything else that braids. Sales manager Denys Heiden told us that the factory generates some 58 million shoelaces every year along with some other impressive products like sewing thread, offshore platform mooring lines, and a deep-sea aramid coring cable.

Cousin Trestec supplied the Superaram COSA® aramid-core cable to the **French Polar Institute's** (IFRTP) research vessel *Marion Dufresne.* Aboard, the 7,500-meter cable connected the Samois system for operating the giant Calypso deep-water piston corer.

Heiden said the cable weighs a mere 1.5 tons at 8,000 meters compared with a steel-wire-core cable with the same specifications that weighs around 12 tons. Last summer, the *Marion Dufresne* and the COSA cable were involved in a record of sorts. Researchers dropping piston corers on the Bermuda Rise in the Sargasso Sea brought back a 53-meter core, which offered an unbroken look at 160,000 years of global change data. Typical cores from the area were only 25 meters or so long and covered only half the time period.

Part of the success of the mission, Heiden added, was use of a new **Kley France** band winch that functions with several cable diameters and limits the number of bends in the COSA cable.

Next stop was several miles away at Brest, located in hilly headlands, which town is considered France's gateway to the Atlantic. It is here where the French navy and the country's famous **Institute Français de Recherche pour l'exploitation de la Mer** (IFREMER) hold forth among a sizeable cluster of oceanographic companies.

Moving Data Acoustically

Underwater acoustics is the specialty of **ORCA Instrumentation** there. Its energetic president Jean Michel Coudeville is typical of many that began at IFREMER and departed a decade ago with a marketable idea and a shout of "Eureka." Since then, Coudeville & Co. is considerably involved in the AUV world. He told *Sea Technology* that ORCA developed the acoustic link portion of the Marius AUV as well as on the follow-on Martin vehicle. Most recently, the firm has furnished the acoustic links for the SAV (surface autonomous vehicle) AUV designed initially to survey shallow-water hydrothermal vents off the Azores. It's a three-year program.

ORCA featured two other product systems at OI 98: its GPS intelligent buoy (GIB) system and a two-way telemetry system for use in severe underwater conditions. GIB in effect ties global positioning system location with underwater vehicles in real time and with differential GPS accuracies, he told us (See *Sea Technology*, April 1998, pp. 31-34.).

Coudeville added that the overall accuracy is 3 meters in the four- to six-buoy net and it can be set up in 20 minutes.

The telemetry system called MATS, for multimodulation acoustic transmission system) allows data movement from vehicles, bottom stations, and offshore oil wells to surface ships or platforms. The operator can optimize the link by selecting modulation and baud rate parameters (between 20 and 4,800 bits per second).

"Operations at sea have been very successful," he said. "Chirp modulation used to transmit commands, for example, resulted frequently in zero error in an entire day's operation."

Within a stone's throw from ORCA are the offices of **MORS Environnement,** builders of acoustic releases, transponders, and telecommand units. The firm also builds and markets its own positioning and navigation units and oceanographic measurement instruments. Company officials told us the firm has sold more than 3,500 acoustic releases and recoverable transponders worldwide—from the "traditional" instrumentation releases (250-kilogram to 5-ton capacities) to the giant versions (300 tons safe working load) operating at down to 6,000 meters for mooring/installation activities.

Departing the business park flavor, our "tour d'France" moved over to the slightly more university-campus-like atmosphere that is IFREMER.

While the U.S. effort in oceanographic research and technology, for example, is spread among 19 or so federal agencies and a slew of universities and research institutions, the "official" ocean community in France *is* IFREMER for all practical purposes.

There, we met with Jean-François Couchouron who directs the Ocean Engineering Department. He told us OED is part of the larger Engineering, Technology & Information Division (DITI) staffed by 240 personnel under a budget of approximately FF100 million (about $17 million).

IFREMER itself spreads itself primarily around Brest and Toulon and another 19 locations in France plus facilities in five other French territories such as Tahiti and New Caledonia. These are work locations for the agency's 1,200 permanent staff and 400 additional personnel.

Couchouron said DITI operates under a relatively simple mission statement: provide the country's ocean science community with the equipment and instruments it needs—including research on basic marine technology, development of instruments and underwater equipment, and development of vessels, test facilities, and databases for the French ocean community.

Coastal environment studies (water quality, ecology, pollution), living resources (fisheries evaluation and aquaculture techniques), ocean/climate investigations (fundamental research, oceanography from space, data archiving from ERS-1 and -2), and deep sea research are the "hot" issues for DITI Couchouron identified for the 1996-2000 timespan.

R/Vs, Sí!—AUVs, No!

"IFREMER currently operates eight research vessels, three submersibles, and other equipment to fulfill its mission. We are planning to build a ninth vessel," he told *Sea Technology.* There currently is no effort underway to develop an autonomous underwater vehicle capability, Couchouron said, because "its use is unclear."

A walking tour of several labs revealed some of the instruments and systems under development at IFREMER. The new Victor ROV was one; now on trials, the vehicle is rated for 6,000-meter depths, connected by fiber optics. Acoustic positioning (ultra-short baseline) at that depth will be accomplished by another OI 98-displayed system called Posidonia 6000 developed by MORS and **Thomson Sintra ASM.** The system uses a single bottom-mounted transponder that offers a positional accuracy of ±10 meters at that depth.

Given the importance of underwater mapping and imaging, IFREMER has released its new state-of-the-art software program "Caraibes" for processing multibeam echosounder and side-scan sonar data. Developed in collaboration with **CAP Gemini** in Brest, the system can gather data simultaneously from several echosounders and sonars, merging the data into cartographic images.

Other firms exhibiting on the French stand but not necessarily on the tour were: • **Martec,** which manufactures a range of subsurface floats for studying large-scale oceanic water movements. Versions discussed in earlier issues are Marvor vertical profiler, VCM-Sivor subsurface monocycle buoy, and Provor, a free-drifter for long-term profiling; • **Météomer,** which firm offers metocean data worldwide; • **Muller,** a designer/manufacturer of steel and light aramid fiber cables; • **Vector Cable Schlumberger,** a source for a variety of offshore oil/ROV/deep ocean instrumentation cables; and • **Technicap,** designer of Perfils deep water sampling pumps. */st/*

Underwater Vertical Digital Communication System

VERTLINK—A Digital Signal Processor-Based System Adapts to Changing Environment, Counteracts Ocean Dynamic Effects

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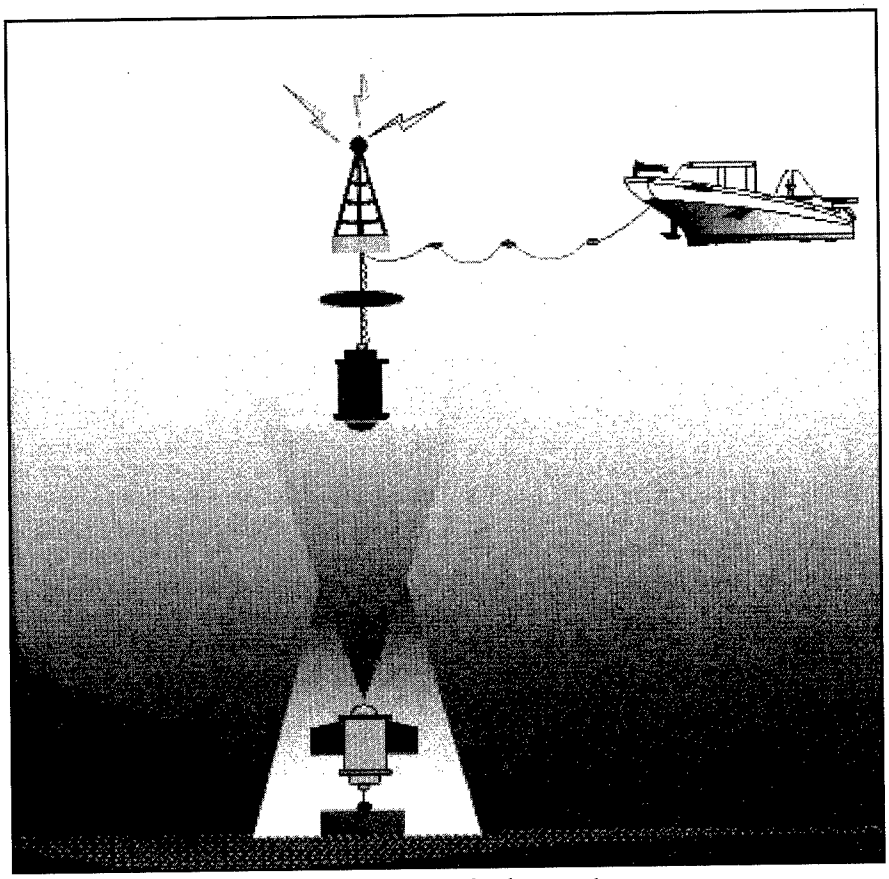


VERTLINK communications system.

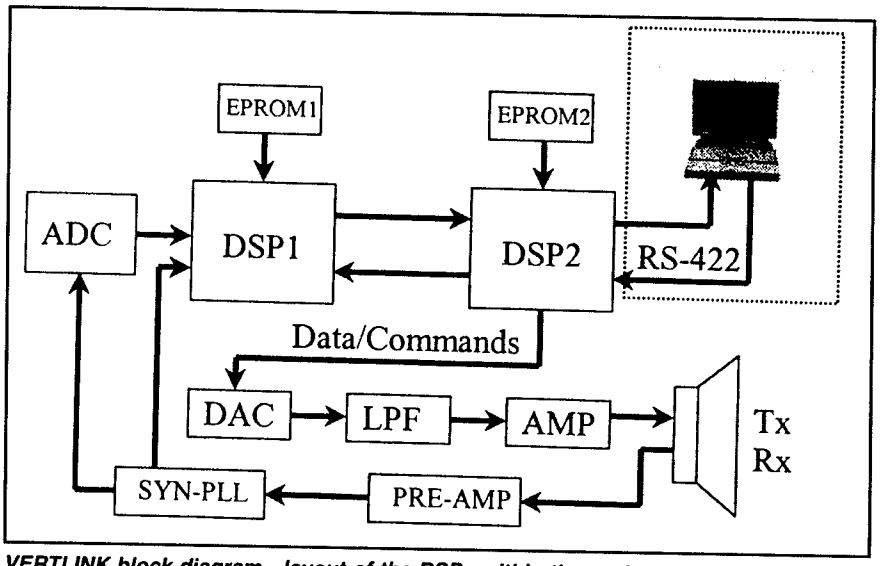
Accurate *in-situ* studies of the ocean environment requires efficient, fast, and reliable communication systems, which provide the command and data link between various instruments deployed underwater. The highly conductive and opaque nature of the ocean rules out the use of the electromagnetic or optical communication methods used by terrestrial systems. Instead, acoustic techniques must be used—a means long recognized as the only effective way to transmit information through the water. Several modulation techniques have been shown by previous researchers to be effective in this task. These modulation techniques include frequency shift keying (FSK), M-ary-FSK, minimum shift keying (MSK), differential phase shift keying (DPSK) and M-ary DPSK.

The current generation of underwater telemetry systems tend to use proven low data rate "discrete-component" designs. These systems perform well in a stable environment but their performance rapidly degenerates when the ocean becomes more dynamic. The next generation of telemetry systems must be able to adapt automatically to the changing oceanic environment and counteract dynamic effects through the use of signal processing routines and flexible detection algorithms. The implementation of these algorithms using conventional "discrete-component" designs is impractical. The solution to the problem is the use of DSP-based underwater communication systems.

A system of this type has been designed and developed to meet the needs of oceanographic studies during the next decade. The system VERTical LINK (VERTLINK) is built around the Analog Devices 2101 fixed-point DSP chips and may be considered the first step in the development of a completely autonomous, adaptive communication system.

General Configuration

This system comprises a seafloor unit (referred to as the "transmitter")



VERTLINK block diagram—layout of the DSPs within the surface and bottom units is illustrated; ADC = analog-to-digital converter; DAC = digital-to-analog converter; DSP1/2 = digital signal processor one/two; EPROM = erasable programmable memory; LPF = low power filter; RS-422 = serial port type 422.

and a surface unit (referred to as the "receiver"). The transmitter is anchored to the seafloor using a disposable ballast and acoustic release, whereas the receiver is deployed above the transmitter and is free to hang beneath a submerged buoy.

The bottom unit acquires and stores oceanographic data in water depths up to one kilometer and transmits this data on-demand to the surface unit and to an end-user. Data transmission is controlled by the surface unit via a personal computer located either on board a nearby research vessel or at a distant land-based station (by means of a radio link.)

The choice of modulation scheme has an important bearing on the performance of the underwater communication system and its realization in a DSP. The chosen modulation scheme should allow large data throughput and also offer some degree of immunity to the deleterious effects that limit the performance of underwater communication links. These effects include scattering from the channel boundaries (the water surface and the seafloor), reverberation, signal fading, and noise contamination.

A review of the literature on underwater communication reveals that until comparatively recently the mainstream modulation technique was multifrequency shift keying (MFSK). This modulation technique is, however, bandwidth inefficient and setting the level of modulation requires hardware.

As a consequence, a technique becoming more popular is multilevel differential phase shift keying (MDPSK). This modulation scheme encodes binary data as phase changes. For example, 2-DPSK has no phase change applied for a binary "0," whereas a 180° phase change is applied for a binary "1." The transmitted data are differentially encoded in order to reduce the time varying effect of the channel. The advantages of MDPSK are that it is more bandwidth efficient than MFSK and that it allows the data throughput to be increased relatively easily by changing the modulation level from 2 to 4 to 8, each symbol transmitted conveying 1, 2, and 3 bits of information.

Theoretically, the level of modulation can be increased indefinitely to increase the data rate. However, an increase in the level of modulation is also accompanied by a reduction in the system's immunity to noise. For example, the maximum allowed phase error for the correction detection of the phase of a signal should be within ±22.5° for 8-phase modulation in comparison with that as much as ±90° for 2-phase modulation.

A few reasons why MDPSK has not been widely employed till now are: first, the circuit complexity needed to decode the data and second, its inferior performance compared to MFSK in combating the effects of fading and inter symbol interference. However, with the advent of more powerful signal processing, the latter has become less of an issue and MDPSK is becoming the logical choice for the next generation of underwater communications systems.

At the University of Birmingham the VERTLINK system has been designed to meet the requirements of

Selected Acronynms

DPSK	Differential phase shift keying
FIR	Finite impulse response
IRQ	External interrupts
MDPSK	Multilevel differential phase shift keying
MFSK	Multifrequency shift keying
MSK	Minimum shift keying
SPort	Serial port

future underwater communication needs.

System Description

The VERTLINK system uses fixed-point, rather than floating-point units, because they required less power and were less expensive. These two factors are important in any underwater communication system, because they are battery powered and are often disposable or difficult to retrieve. Although floating-point processors offer a large numerical dynamic range, this is unnecessary in the application as in most underwater applications.

Essentially, the surface and seafloor units are identical. Both units contain two DSPs. One difference is that the second DSP (DSP2) on the surface unit communicates with a personal computer, either directly or via a radio link. The DSPs detect the modulation and demodulation of the data and commands—all data are transferred through them using their serial ports (SPort).

The sampling of the analogue signal at the input of the analogue-to-digital converter is controlled by the first processor using its internal timer. The internal timer generates interrupts after a predefined number of processor cycles. The sampling frequency is limited by the speed at which the processor operates. The maximum sampling frequency that can be achieved is equal to the reciprocal of the sampling period, "T," which can be found by determining the number of operations, "n," executed by the processor for each sample multiplied by the processor cycle, "T_{cp}":

$$T = n \bullet T_{cp}$$

For each interrupt the processor reads the data sample at the output of the analogue-to-digital converter and starts the next data sample conversion.

50 kHz-Carrier FIR
(10 KBPS Symbol Rate, Filter Order 7)

Parameter	*kHz*
Sampling frequency	200
Cut-off frequency	10
Bandstop	70
	dB
Bandpass attenuation	0.5
Minimum bandstop	35.0

The analogue-to-digital converter is unipolar and generates an output between "0" and "1." This signal is made bipolar by subtracting 0.5 and then scaling up by "2." This gives a dynamic range from "-1 to +1."

In the first DSP each sample is multiplied by sine and cosine signals at the carrier frequency generated within the DSP. The result of these operations are filtered using finite impulse response (FIR) digital filters to produce the in-phase (I) and the quadrature (Q) phase components.

To achieve optimum performance the VERTLINK system is designed to work at a number of different frequencies. The choice of frequency depends

on the operational depth. The FIR parameters can be modified to achieve the required bandpass boundaries and band stop attenuation. The order of the digital filter determines the number of operations needed to implement the filter (the number of processor cycles needed to implement an FIR filter is equal to the order of that filter plus six processor cycles). The samples at the output of these filters are sent to the second processor using the serial ports. All the programs running on the DSPs are interrupt driven, as follows:

"MDPSK is becoming the logical choice for the next generation of underwater communications systems. At the University of Birmingham the VERTLINK system has been designed to meet the requirements of future underwater communication needs."

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1. The start interrupt is used to boot up the processor.
2. The IRQ2 interrupt is generated externally by the hardware.
3. The SPort interrupts (up to 4) include input and output interrupts for each SPort. These generate interrupts after receiving or transmitting data. Depending on the configuration of the serial ports, interrupts can be generated after a single word (from three to 16 bits) or after buffer of data has been transmitted or received (using the autobuffering capability of the processor).
4. The timer interrupt is generated by the internal timer after a number of processor cycles.
5. Depending on the configuration of the DSP's control registers, the second serial port (SPort1) can be configured as a proper serial port or as two additional external interrupts (IRQ1, IRQ2).

System Operation

Typically, after deployment at sea, the VERTLINK system seafloor unit records oceanographic data, such as seismic activity, current flows, temperature, salinity etc. These data are stored in the system's volatile RAM or on its hard disk.

An end-user located either nearby, on a research vessel, or at a land-based station interacts with the seafloor unit using software written for Windows 95 using Visual C++. The graphical user interface (GUI) software makes use of the standard COMM.DRV library to access the USART device of the personal computer.

This interface allows the end-user to:

- Define the transmission parameters (baud rate, type of parity, number of stop bits)
- Open or close a connection with the seafloor unit
- Send a command to the seafloor unit
- Affect data recording and storing.

The command selected by the end-user is sent from the PC and is received by DSP2 on the surface unit. The DSP frames this data using start, stop, and parity bits and then modulates the data to the seafloor unit using the lowest

DPSK Efficiency and S/N

Modulation Level (M)	*BW Efficiency (bps/Hz)*	*S/N (dB)*
2	1	9.59
4	2	11.94
8	3	18.3

modulation level (2-DPSK). The lowest modulation level is used to minimize error probability at the receiver.

The receive and transmitter process interrupts from both serial ports of the DSPs (SPort0 and SPort1). The interrupts on SPort0 come from the first DSP on the board, whilst the interrupts on SPort1 come from the interface with the PC.

When first powered up, the seafloor unit enters a continuous loop and monitors for interrupts. When an interrupt occurs the signal is decoded and checked to see if it is one of the commands. Commands are distinguished by checking the most significant bit. If the bit is a "1," the received byte is a command. The seafloor unit receives the commands from the surface unit and decodes and executes them. If the seafloor unit is requested to transmit data, the stored data is formatted and used to modulate the carrier signal and transmit the information to the surface receiver.

The modulation/demodulation processes are the same in each unit and are performed by the pair of DSPs using the procedure discussed earlier. DSP2 performs the decoding process in three steps:

- Comparison of the magnitude and sign of the in-phase and quadrature components to recover the signal phase value
- Comparison of the phase value with the previous one (or with the "0°" reference at the beginning of the stream) to evaluate the phase difference
- Extraction of the binary symbol (1, 2 or 3 bits according to the modulation technique) from the relative phase value using a local look-up table.

The binary digits are buffered to build up an 8-bit word framed with start, parity, and stop bits and finally sent to the PC through SPort1.

Conclusions

The VERTLINK acoustic telemetry system was designed to address the problems of oceanographic data collection in water depths of up to one kilometer. VERTLINK doesn't yet implement detection algorithms but this is the next stage in its testing. The system does, however, form the platform onto which more complex, adaptive underwater systems can be developed. This has been assured by using DSP chips.

The results collected so far are very promising. Further development and testing of the system are planned and this will lead towards a new generation of underwater telemetry systems. /st/

Acknowledgments

The assistance and guidance of many who have made this research possible, in particular, friends and colleagues at Birmingham University who have assisted in this project in so many ways.

This work was funded by the European Communities under contract n.MAS2-CT94-0079.

John C. Jones' career began in 1986 when he was employed as an instrument and control engineer by the Whitebread Beer Co. (South, Wales) for four years. Subsequently he obtained a degree in electronics and then worked in the Acoustics and Sonar Group of the University of Birmingham for three years to develop a vertical underwater communication system. During the same period he studied for his doctorate.

Alberto Di Meglio obtained a masters degree in aerospace engineering from Politecnico di Milano (Italy) in 1993. In 1995 he was appointed as research associate in the School of Electronic and Electrical Engineering, University of Birmingham, where he stayed until December 1997 as a member of the Acoustics and Sonar Group. Di Meglio is presently working as network systems analyst at CERN and writing his doctorate thesis on the application of boundary elements to the dynamic analysis of viscoelastic, sound-absorbent baffle materials.

Dr. Lian Sheng Wang received his bachelor's and master's of engineering from Harbin Engineering University (China) and doctorate in physics from University of Bath (England). He is an academic staff member of Acoustics and Sonar Group. Wang has been involved in research in sound propagation in the shallow-water channel with various bottom profiles, signal processing, underwater acoustic communication, and non-linear acoustics.

Dr. Nafa Aid graduated in electronics at the University of Algiers in 1984 and received a doctorate in digital signal processing in 1990 at the University of Birmingham. He worked as a research fellow from 1990 to 1996 at the University of Birmingham in the area of underwater communication. Now he is a senior software engineer in mobile communications with Simoco Telecommunications.

Optic Control of Undulating Platform

Undulating Towed Vehicle SeaSoar Converted to Fiber-Optic Control and Telemetry—Data Bandwith Increased

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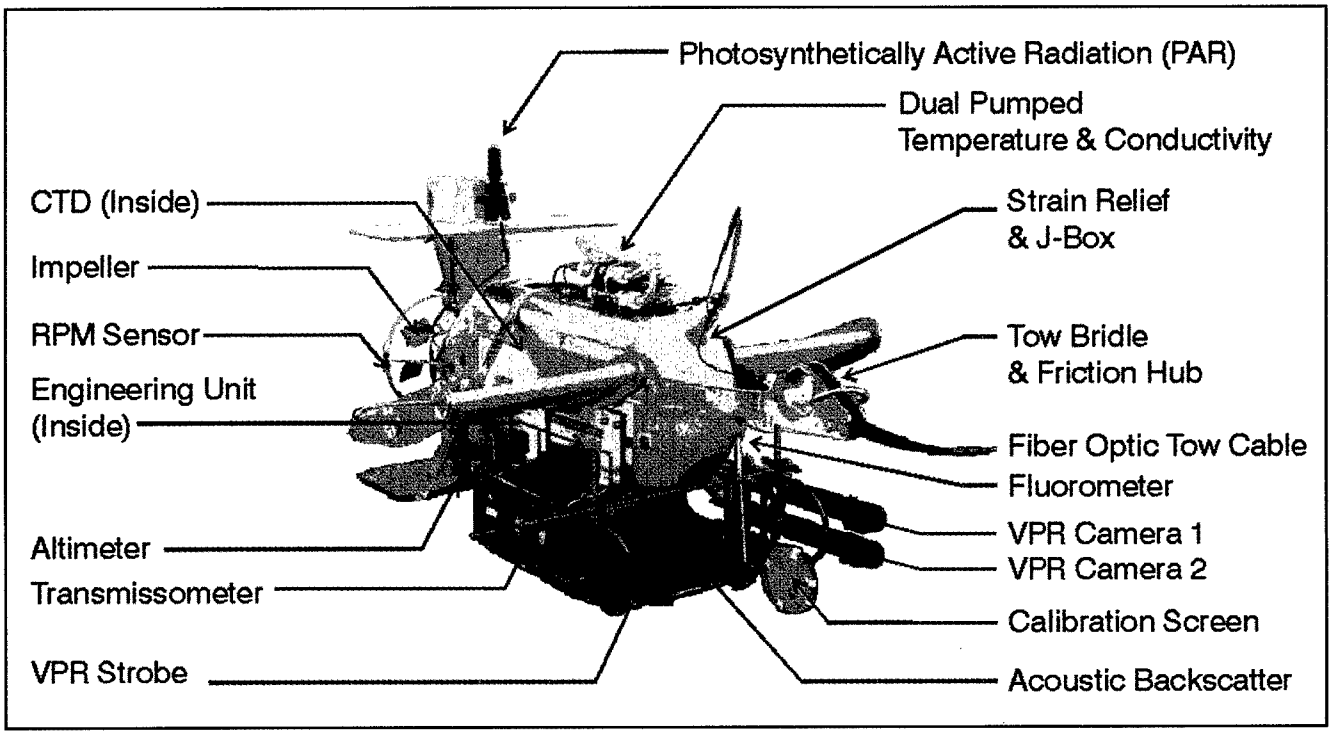
Woods Hole Oceanographic Institution (WHOI) operates the towed undulating vehicle SeaSoar, the sensor suite of which typically measures CTD, light attenuation, chlorophyll, photosynthetically active radiation (PAR), bioluminescence, and acoustic backscatter. When towed at 8 knots with 1,000 meters of cable (500 meters faired), the vertical range extends from the surface down to 350 meters with a horizontal cycle spacing of 3 kilometers. A bottom-avoidance system allows flight to less than 10 meters off of the seafloor.

A new winch with 500 meters of cable (40 faired) has a profiling range typically within 2 meters of the surface down to 130 meters. It is used in shallow water mode (less than 120 meters depth). Both configurations have seen extensive use.

The 1,000-meter cable for deep tows, a seven-conductor copper-based load-bearing cable, used two conductors for control and three for telemetry. A new cable uses a novel design that has three single-mode optical fibers, each surrounded by a copper conductor enclosed within a two-layer steel jacket.

Motivation for the conversion to a fiber-optic tow cable was to support the WHOI video plankton recorder (VPR). Experiments were made using balanced video on the existing seven-conductor cable, but cross talk from the CTD and other communication devices in the vehicle made the images unusable. Coaxial/single conductor cables were considered, but the cable



SeaSoar vehicle and sensor placement.

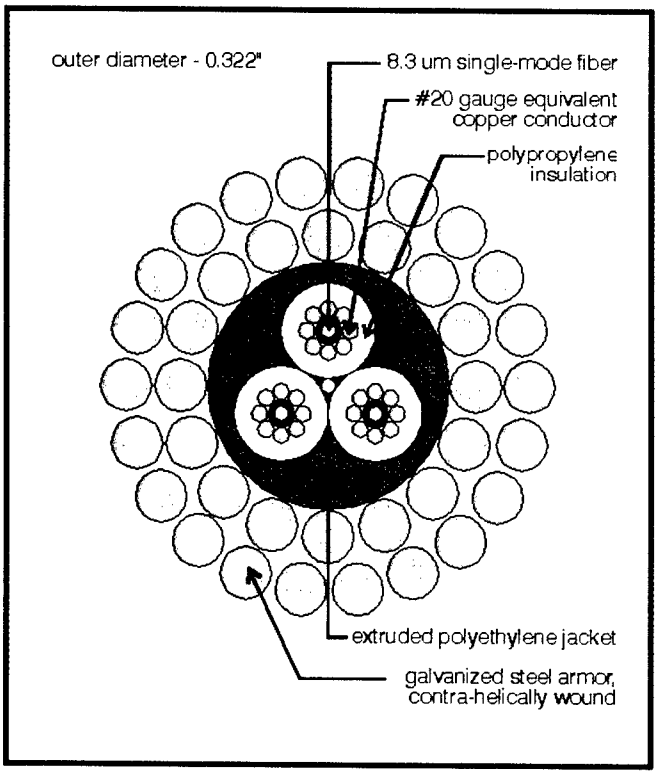
diameter exceeded the target of 0.322 inches. A cable offering three fibers and four conductors would support telemetry, control, and power.

One conductor and the armor return operates the Bellevue, Washington Sea-Bird Electronics Inc. (SBE) 911+ CTD and the other two conductors supply power to the 35 watt load of the VPR and fiber drivers.

Sensors supported via the CTD in SeaSoar's current configuration include: two temperature and two conductivity sensors and associated pumps, a spherical collector PAR plus downwelling and upwelling PARs, Datasonics Inc. (Cataumet, Massachusetts) altimeter, Wet Labs Inc. (Philomath, Oregon) flourometer and transmissometer, a WHOI bathyphotometer, and the VPR strobe and two cameras.

Because there was a reduction in the number of copper conductors, there had to be a redistribution of some of the flight controlling functions for the vehicle normally performed at the surface. SeaSoar uses a current-controlled Moog Inc. (East Aurora, New York) hydraulic valve for wing control. (Power to move the wings is derived from an impeller-driven hydraulic pump.) Previously, current for control of this valve was generated and monitored at the surface and was sent down to the vehicle as part of a current loop.

The new subsurface controller VPR Engineering Unit (VPREU) telemeters vehicle flight data such as pitch, roll, pressure (depth), impeller rpm, wing angle, and hydraulic control valve current. An open-collector communications link for commanding the VPREU, and a 12-bit bipolar current source for the hydraulic control valve are also implemented in the VPREU. Control signals and VPREU data are sent bidirectionally over the same fiber. Additionally, the primary telemetry channel supports No.1 video camera. A second video-to-fiber converter operates No.2 camera. Wide-range DC-DC converters power the electronics and the fiber transceivers.



Rochester Corp. Electrolight cable.

Fiber-optic-based cables have had considerable application in ROVs, but an undulating vehicle operating in a wide range of depths poses some unique problems. Since the loss of telemetry is a major concern, a high-reliability stainless-steel pressure housing containing a hardwired watchdog circuit monitors power and data transactions in the VPREU. If a power loss occurs, or if data is not received for three seconds, a battery and series limiting resistor sends "up wing" current to the hydraulic control valve. This is important when working in shallow water. If the wings were in the "down" position and the surface flying computer were to fail, or if there was a telemetry loss, the vehicle could crash into the seafloor.

Bidirectional EIA-232 9600 baud communication and video for camera No.1 is maintained over one of the fibers by an Optelecom (Gaitherburg, Maryland) (TM) 9716 module transmit/receive pair. Because the tow cable uses single-mode fiber, the emitter for this transceiver requires a solid state laser. Two different laser wavelengths are used. The transmitter uses 1550 nanometer for video and data, and the receiver uses 1310 nanometers

for data only. The optical output of the transmitter is considerable; our experiments show reliable communications and video even with poor terminations and severe cable bending. Power consumption is nominally 250 milliamperes at 12 volts. A second fiber carries VPR camera No.2 video and uses a video-to-fiber only transmitter/receiver pair. The third fiber is designated as a spare but is available for a third camera or telemetry link.

Cable Terminations

The fiber optic sea cable is terminated in the winch hub. To avoid the need for fiber-optic or coaxial slip rings, video is converted to a balanced baseband signal. The deck cable is 50 meters long and is made of a commonly available twisted pair communication cable. All communication and power is brought in through the slip ring. The deck unit consists of a power supply for hub electronics (two fiber-to-video converters and the balanced drivers), a parallel port to serial-data converter, two balanced video receivers, and the power supply for the VPR.

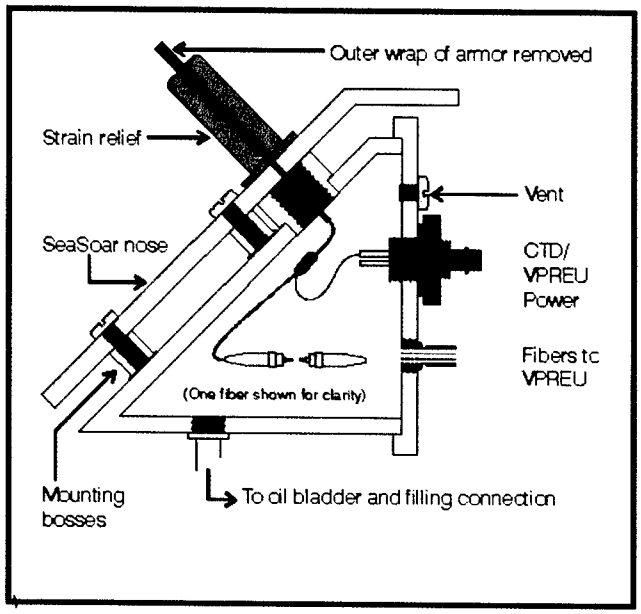
The other major component is a SBE 911+ deck unit. The previous (copper-only tow cable) digital controller used a PC's parallel port to control current going to the wing hydraulic control valve. Depth data returned from the CTD, VPREU, and altimeter are used by the flight PC to set the wings to follow an undulating path. To maintain vehicle-flight software qualification, a simple parallel-to-serial conversion circuit allowed the original copper cable flight software to be used.

The new sea cable is a Rochester Corp. (Culpeper, Virginia) Electrolight (TM) cable which offers a total of three fibers, three copper conductors, and the steel armor as a conductor which is used as the primary power return for the CTD. Construction is a buffered 8.3-micrometer single-mode fiber, a #20-equivalent-gauge copper conductor over the fiber buffer, and insulation over the copper/fiber coax. The three coaxial fibers/copper assemblies are wrapped around a filler.

A buffering jacket and a dual steel contra-helically wound jacket surrounds this bundle. Breaking strength is rated at 11,600 pounds with a maximum working load of 2,500 pounds—we experience tensions below 2,000 pounds. The specified bend radius is 5.15 inches. Although the radius of the tow-point friction hub on the SeaSoar bridle is only 2 inches, it appears that if the tight bend in the cable is static, it performs well with no noticeable degradation of signal. (The tow point on the deck is a distributed-roller-type sheave supported from the A-frame.) There have been no fiber losses with over 250 hours of towing and numerous launches and recoveries in rough conditions.

Because of space restrictions in the vehicle, a compact junction box (J-box) was built. This pressure compensated enclosure is the termination point for the sea cable to VPREU and CTD. Mineral oil was selected as the compensating fluid for its good dielectric characteristic and because it does not attack cable insulation or seals. In the J-box as in the winch hub, the fibers are broken out into their elements.

Connection to the copper conductors is made by using low-temperature solder rings. The optical fibers are terminated with fiber optic "ST" connectors. Because the "ST" connectors are



Pressure compensated junction box for the sea cable to VPREU and CTD.

at the voltage potential of the conductor, insulating plastic couplers are used. A bladder is used as an oil reservoir and a sump for water collection. A quick disconnect filling on the bladder is used for filling the J-box.

In summary, the bandwidth-limited copper cable has been replaced by a fiber system that provides bandwidth that was never imagined in the early days of the SeaSoar. We are currently developing a subsurface multiple-communications core to support a new generation of optical instruments with demanding bandwidth requirements. */st/*

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Paul Fucile is a research engineer in the Physical Oceanography department at WHOI. He holds a bachelor's of science in electrical engineering from Worcester Polytechnic Institute. Fucile's interests are in low level analog circuits and optical sensors.

Frank Bahr is a research associate and is the Sea Soar Group manager. He holds a master's degree from University of Hawaii and an undergraduate degree from Kiel University. Bahr's interests are shipboard and lowered ADCP applications and real-time scientific computing.

Allen Gordon is a senior research assistant in the Applied Ocean and Physics department of WHOI. He has been involved with the Alvin Group for over 10 years. Gordon holds a bachelor's of science degree from Bates and an associate of science degree from Wentworth Institute.

Jerry Dean is an oceanographer emeritus at WHOI. He holds a bachelor's degree in electrical engineering from Virginia Tech. Dean has provided engineering and SeaSoar operations support since 1991.

Capital Report

Daley Approves Full Production Of 95 AWIPS Units for NWS

Commerce Secretary William M. Daley has approved the National Weather Service's plan for a full production and installation of interactive weather computer and communications systems that will help provide better weather- and flood-related services to protect life and property. The recent decision authorizes production of 95 additional systems necessary to improve the data flow and forecast and warning services of NWS. In total, 152 advanced weather interactive processing systems (AWIPS) will be installed nationwide by the end of FY 1999.

"Completing the National Weather Service modernization is the top priority with [NOAA]," said Dr. D. James Baker, undersecretary of commerce for oceans & atmosphere. "AWIPS lets our forecasters display weather data in a variety of ways, quickly analyze evolving weather systems, and issue timely forecasts and warnings for the protection of life and property."

AWIPS will replace the service's existing 1970s-era weather communications system known as automation of field operations and services (AFOS). AWIPS will allow forecasters to display and analyze satellite imagery, radar data, automated weather observations, and computer-generated numerical forecasts, all in one workstation. The system is being developed by the NWS, NOAA's Forecast Systems Laboratory in Boulder, Colorado, and PRC Inc. of McLean, Virginia.

"The feedback I get from our offices that already have AWIPS is that it's an outstanding tool," said Jack Kelly, NOAA assistant administrator for weather services. "Before AWIPS, our forecasters relied on three or more systems to view the information needed to produce forecasts and warnings. With AWIPS, our forecasters can quickly see and use weather data from a variety of systems, all at one workstation."

Over the past year, early versions of the sophisticated workstation and communications network were installed at a number of sites around the country for operational testing and evaluation. The tests demonstrated AWIPS' capabilities, including communication of weather satellite imagery and weather forecast guidance via a satellite broadcast network; the state-of-art workstation's ability to display and manipulate radar, satellite, and other weather data; and the operations of a central monitoring and communications facility. NWS is using an incremental software development approach for this program as a risk reduction measure. Seventeen systems were installed for test and evaluation. Another 21 systems were authorized in early 1997 for a limited deployment; installation of these systems is complete. An order for 19 additional limited deployment systems was placed in December 1997; installation of these 19 systems begins in June. By accelerating the installation of the remaining 95 systems to an average of 10 per month, NWS will complete deployment by June 1999.

Defense Department Selects Next Generation Internet Bids

The Department of Defense recently announced that it will invest $50 million over the next three years in more than 27 proposals selected for negotiation as part of the federal government's Next Generation Internet (NGI) initiative. The Defense Advanced Research Projects Agency (DARPA) will oversee the program.

The NGI is a multi-agency, federal R&D program that aims to advance networking technologies and new applications through deployment of national-scale testbeds that are vastly superior to today's Internet.

"In the coming years, this investment may enable the best medical specialists to give advice to patients in rural hospitals, scientists to use remote supercomputers to predict tornadoes, and adults to get new skills through distant learning," said Vice President Al Gore about the NGI initiative. Secretary of Defense William Cohen noted, "Internet technology was first demonstrated by the military in the 1970s and is the foundation of today's military and commercial network sys-

tems. The military must stay ahead in information technologies to dominate in the future. The Next Generation Internet program will enable revolutionary capabilities of importance to both the Department of Defense and the nation as a whole."

Under DARPA's portion of the interagency NGI program, performers will develop key technologies for ultra high-performance networks. The research areas include: an architecture combining Internet protocol and wavelength division multiplexing technologies to enable a streamlined approach to the national information infrastructure of the 21st century; ultra-fast optical cross-connect switches; agile network access modules; high-fidelity modeling and simulation techniques; and tools for automating network operations. Many of the prototype technologies and advanced applications will be deployed on SuperNet, DARPA's new, wide-area experimental testbed.

Close to 100 leading research groups across the country competed for the DARPA-sponsored NGI awards, which range from approximately $200,000 to $5 million each. The actual amount to be awarded to each research group is subject to negotiation. DARPA also plans additional awards in excess of $5 million; these awards will be announced at a later date.

Year of the Ocean Web Site Makes a Splash, Offers Data

Did you know that the United States is the world's fifth largest seafood harvester? And did you know that 80 percent of pollution to the marine environment comes from land-based sources?

NOAA officials intend to lead the U.S. Year of the Ocean effort and have designated **http://www.yoto.com** the official web site of the Year of the Ocean. President Bill Clinton officially proclaimed 1998 as "Year of the Ocean" in January, following a declaration by the United Nations for an International Year of the Ocean. Clinton said, "We must strive together—at local, national, and international levels—to preserve the ocean's health, to protect the marine environment, and to ensure the sustainable management of the myriad resources the ocean contains."

The ocean agency's mission is to reach as many people as possible and raise public awareness and understanding of the ocean and related issues. The Environmental News Network and the National Fish & Wildlife Foundation collaborated on the development of the Internet web site, which provides news, a calendar of events, and information on a variety of ocean-related topics including recreation, entertainment, coastal living, conservation, education, and fisheries. The site is updated daily.

Sea Grant Identifies New Ways To Eliminate Zebra Mussels

Since the discovery of zebra mussels in North American waters 10 years ago, scientists have been investigating ways to control the pesky mollusk that has become famous for clogging boat intakes and electric and water facility intake pipes. One critical point in zebra mussel control is the prevention of settlement of their larvae, called veligers.

Two New York Sea Grant research teams have identified technologies that eliminate the zebra mussel veliger. One method, developed by Linda Chalker-Scott and her team, involves zapping larvae with high-intensity ultraviolet radiation. Chalker-Scott and her colleagues found that, in the lab, brief ultraviolet exposure (1 to 2 seconds) paralyzes the veligers for nearly 20 minutes. This is enough time for the larvae to be swept through most water intake systems, prohibiting settlement and colonization on intake pipes. The researchers also found that a longer exposure of 5 seconds killed the veligers instantly.

According to Chalker-Scott, the UV prototype is currently being used by a private company seeking to market a control device.

Another project, led by New York Sea Grant researcher John Van Benschoten, examined what effects coagulants have on controlling zebra mussels. Coagulants are chemicals that cause particles in the water to stick together and form a mass. Van Benschoten and his colleagues recognized early in the study that the coagulants could have potential adverse effects due to the formation and settlement of floc (the mass formed by coagulants) in the intake pipes. They found that coagulants killed veligers largely because they make water more acidic. As a result, the scientists concluded that mild acidification of water at the intake shows great potential for water utilities needing to control mussels. /st/

Environmental Monitoring

January, February 1998 Warmest, Wettest on Record

The first two months of 1998 were the warmest and wettest in the 104-year history of temperatures and precipitation measurements for the contiguous 48 states according to National Oceanic & Atmospheric Administration (NOAA). During this period the national average temperature was 37.5°F compared with a normal of 32.1°F—the previous record was 37.0°F in 1990. For precipitation, 6.01 inches fell, compared with a normal of 4.05 inches. The previous record was 5.7 inches in 1979.

For the winter as a whole (December through February) the temperatures and precipitation were not extreme. Last winter was the second warmest and seventh wettest. California and North Dakota had their wettest February on record. The warmest February on record took place in much of the upper Midwest (Minnesota, Wisconsin, Illinois, Michigan, and Ohio) and parts of the East (Pennsylvania and Connecticut).

"These are the patterns one would typically expect during a strong El Niño event," said Ants Leetmaa, director of NOAA's Climate Prediction Center (Camp Springs, Maryland).

El Niño conditions in the tropical Pacific will gradually decrease during the summer months. Ocean temperatures in this region are expected to be near normal later in the year.

Ozone Depleting Chemicals Continue to Increase

Despite the ban on the production of ozone depleting halons by developed countries, the compounds continue to increase in the atmosphere. Measurements by NOAA's Climate Monitoring and Diagnostics Laboratory (Boulder, Colorado) indicate that three bromine-containing extinguishants (halons H-1211, H-1301, and H-2402) are still being released into the atmosphere in crucial amounts.

Scientists are concerned because the halon bromine is 50 times more efficient at depleting ozone in the atmosphere than the halon chlorine [a component of chlorofluorocarbons (CFCs)] because the gases last a long time in the atmosphere. In 1994, China generated 90 percent of the global production of halons. Continued increases in production in developing countries are allowed within the Montreal Protocol until 2002, at which time countries will have to freeze production at 1995-1997 levels.

Martin 200 AUV Development—Accuracy in Navigation

An extremely accurate navigation and positioning system tested for the Martin 200 AUV is the result of a close co-operation between the Danish company Maridan and U.S-based Kearfott Guidance & Navigation Corp.

Kearfott is providing its advanced technology SEANAV™ inertial navigator for use onboard the Martin 200 AUV from Maridan. It will be the prime positioning system of the AUV in combination with updates from doppler sonar and differential GPS.

"The adoption of the high-precision Kearfott system has enabled us to solve one of the major positioning problems facing the industry for this type of AUV", says Jens Pind, marketing and sales manager for Maridan. "For the first time the survey industry can control and determine both the trajectory and the position of the AUV to an extremely high precision without the need for externally applied signals or dedicated tracking on the surface by a mother ship.

The SEANAV™ inertial platform is based on Kearfott's advanced ring laser gyro technology and is the result of the company's widely based experience in the development of inertial guidance and navigation systems for the military and space industries. From an initialization and precalibration routine performed on the surface with the aid of differential GPS, the SEANAV™ continuously computes all attitude, heading, position, and navigation data required by the Martin 200 mission without aid or control from external signals.

The software has been developed in close cooperation with Technical University of Denmark and the Danish National Laboratory, Ris. /st/

Offshore Oil & Ocean Engineering

Oceaneering, Sonsub Expand ROV Fleet

Oceaneering International Inc. (Houston) announced another expansion of its ROV fleet. The company will manufacture eight new Hydra® MILLENNIUMs and six new Hydra® MAGNUMs for delivery by December 1998. The Hydra MELLENNIUM is a 150-horsepower, high-performance, work-class ROV developed specifically to operate in water depths greater than 10,000 feet and for shallower applications that may require specialized work capability. This includes the ability to run and operate tools, such as large dredge and jet pumps that require very high hydraulic fluid flow volumes. The highly reliable, standardized MILLENNIUM is based on the proven Hydra MAGNUM series design with higher horsepower, deeper water-depth capability, and a heavier payload capacity. It utilizes the newly developed MAGNUM cage design, which allows vehicles of either series to carry and operate work packages of any shape and size suitable for ROV deployment.

MAGNUM ROVs are high-thrust, cage-deployed vehicles designed to accommodate a variety of sensor and work packages supporting the oil and gas drilling, construction, and production activities. These 100-horsepower units operate in water depths down to 10,000 feet and are being manufactured using the latest technology.

In response to the growing demand for its deepwater remote intervention capabilities, Sonsub International (Houston) will increase its current worldwide fleet of ROVS by over 30 percent over the next few years, bringing its fleet of ROVs to approximately 60 vehicles worldwide. The new vehicles will be custom-built to Sonsub's criteria and will include 100-horsepower hydraulic power units, dual manipulators and the capability of attaining depths to 10,000 feet of water. Bids for the ROV base equipment are now being evaluated. Sonsub will procure key proprietary ROV system components and peripheral equipment and will perform the integration of all subsystems.

Racal's Black Sea ROV Pipeline Survey to be Deepest Ever

Petergaz (Russia) has awarded Racal NeSA (Chessington, Surrey, United Kingdom), a unit of Racal Survey, the contract for a high-resolution route survey for the Russia-to-Turkey Black Sea gas pipeline for completion in May. The route ranges in depth from 100 to 2,200 meters and, when completed, the 400-kilometer pipeline between Djugba, Russia and Samsun, Turkey will be 30 per cent deeper than any pipeline currently in existence. The need for high-resolution data will consequently require Racal to undertake the deepest-ever survey using a ROV.

The ROV will be equipped with a SeaBat multibeam echo sounder, side-scan sonar, and a sub-bottom profiler. Special housings capable of withstanding pressures above 250 bar are being custom-made for the instrumentation to ensure operation at these depths. The need for precise positioning at depth is expected to present the greatest technical challenge. Therefore Racal will use the Russian R/V *Gelendzhik* equipped with a Sonardyne long, ultra-short baseline (LUSBL) system with the transceiver mounted in the ship's moon pool. In addition, the ROV will be fitted with two mini-RovNav systems supported by special deep-rated transponders. The LUSBL system will also provide conventional acoustic ROV tracking and positioning. The *Gelendzhik* will also be equipped with a deep-tow side-scan sonar and a full ocean depth EM 12 multibeam echo sounder.

All ROV sensor data will go into a RTSX ROV logging computer system. The software will preclean multibeam echo sounder scans and provide doppler-enhanced subsea positioning. Two separate files will be networked to a Sun SPARC workstation on the ship and will enable complete XYZ profiles of the seabed to be prepared. These will enable the Petergaz representative to modify survey activity as circumstances demand.

A feasibility study by Petergaz and Racal last May confirmed that, after steep descents close to the Russian and

Turkish coastlines, some 70 per cent of the proposed route will be over the featureless abyssal plain. Although potentially straightforward as a pipeline route, the extreme water depths are expected to impose significant technical demands. These include working in water with unusually high corrosive characteristics and will require the ROV to be fitted generously with conventional and aluminum anodes.

Stratos Mobile Networks Provides VTS to Canadian Coast Guard

Stratos Mobile Networks (Canada), with Racal (United Kingdom), and Software Kinetics Ltd. (Canada) have an agreement with the Canadian Coast Guard to supply FLAG 11 VTS systems for 125 vessels. The $2.1 million contract (after a $300,000 pilot project) provides the Canadian Coast Guard with vessel location information through six Locator VTS control centers supplied by Racal. Locator was chosen for the FLAG 11 system from Stratos because it provides tightly integrated graphics as part of an intelligent data management system.

FLAG 11 is a distributed information system designed to work with many communications systems, but presently uses the North American MSAT mobile satellite system to serve the Canadian Coast Guard. For the initial two-year period the data will be sent from the vessel to the control centers via the Stratos operations center, where the vessels will be tracked and all locations updated regularly. The 125 MSAT satellite terminals aboard the vessels are all part of the FLAG 11 service package. Forty-one units are already installed, and the remaining 84 satellite terminals along with the complete FLAG 11 system will be operational by July 1998.

Shell Adds Three New Deepwater Developments; Other Activities

Shell Exploration & Production Co. announced plans to spend nearly $1 billion to develop three oil and gas discoveries that will add over 300 million barrels of oil equivalent to the Gulf's deepwater inventory. These three projects—Angus, Europa, and Macaroni—will increase Shell's number of deepwater developments to 14, the most in the industry. Each project will be developed utilizing subsea systems tied back to existing platforms.

Rich Pattarozzi, president and CEO of Shell Deepwater Development Inc. said, "With these projects, we have been able to capitalize on our growing infrastructure in the deep water to allow cost effective development of smaller discoveries to shorten the time from start of development to first production."

- The Macaroni development, owned 100 percent by Shell Deepwater Development, will consist of three subsea wells located in 3,700 feet of water in Garden Banks Block 602. Macaroni will tie back 12 miles to Shell's Auger tension leg platform (TLP) for production processing. Production is scheduled to commence midyear 1999. Peak production rates are anticipated to be 35,000 barrels of oil/day and 65 million cubic feet of gas/day.
- The Angus development, a four-well subsea system located in Green Canyon Block 113 in about 2,000 feet of water, is a joint effort by Shell Deepwater Development (as operator) with 80 percent interest and Marathon Oil Co. with 20 percent interest in the project. Discussions are currently underway to tie back the wells to Shell's Bullwinkle fixed platform on Green Canyon Block 65, about 12 miles away. Production is estimated to begin in the second quarter 1999, with peak production rates of 40,000 barrels of oil/day and 60 million cubic feet of gas/day. Talks are also being conducted to tie back the wells on Marathon's Green Canyon Block 112 to Bullwinkle, where Marathon has a 65 percent working interest and Shell has a 35 percent working interest.
- Europa, located in approximately 3,900 feet of water in Mississippi Canyon Blocks 934, 935, 890, and 891, initially will be developed using four subsea wells tied back to Shell's Mars TLP in Mississippi Canyon Block 807 approximately 20 miles away. Shell Deepwater Development, as operator, has 66 percent interest in the project, with BP Exploration Inc. and Conoco holding 33 percent and 1 percent respectively. Production is scheduled to begin in early 2000. Peak production rates are anticipated to be 60,000 barrels of oil/day and 45 million cubic feet of gas/day.

Shell was high bidder on 129 of the 158 blocks on which they bid in recent Gulf of Mexico block lease sale (#169). Shell bid alone on 73 blocks and with partners on 85 blocks. */st/*

Ocean Research

Unique Thermostable Enzymes in Hydrothermal Vent Worm

Diversa Corp. (San Diego, California) discovered unique, thermostable enzymes located in the symbiotic bacteria associated with the Pompeii hydrothermal vent worm (*Alvinella pompejana*). Scientists at Diversa, the University of Delaware, and Rutgers University reported data showing the Pompeii worm to be the most eurythermal (thriving in all temperatures) organism and thermotolerant metazoan yet discovered. Some of the symbiotic bacteria residing on the worm appear to be closely related to a human pathogenic bacterium called *Helicobacter*, known to cause ulcers in humans. Study of these bacteria could lead to the development of more effective pharmaceuticals. In an effort to determine what enables the Pompeii worm and its associated microflora to survive at such extreme conditions, Diversa has created DNA libraries and sequenced and screened thousands of clones from the symbiont samples.

Diversa went to 1.5 miles deep to locate unique enzymes with utility in commercial processes and pharmaceutical development. One of the most intriguing enzymes discovered from these microorganisms is an esterase capable of functioning throughout a range of temperature conditions including a high temperature capability reaching up to 176°F. The organism can survive with a 140°F-temperature range in its body at one particular time.

The symbiotic proteobacteria, which survive along the dorsal surface of the animal, are unique in their ability to survive in this extreme environment. Diversa is studying the enzymes of these symbionts because of their high activity over extended temperature ranges, making them potentially useful as biocatalysts. Heat tolerant enzymes offer endless biocatalyst possibilities for the advancement of textile, detergent, and other industrial processes worldwide. But it is the potential to increase knowledge in the health care arena that is of great interest.

Diversa believes that the enzymes of the Pompeii worm and its symbionts may provide clues as to how these organisms can survive in such an extreme environment. It will he useful to see how a bacteria with known pathogenic relatives can co-exist with a higher organism like the Pompeii worm.

Lead Levels from Leaded Gasoline in Atlantic Reduced

Concentrations of lead in the Atlantic Ocean have dropped dramatically 18 years after the Clean Air Act banned lead from gasoline, an MIT scientist said at the 1998 ocean sciences meeting of the American Geophysical Union and the American Society of Limnology and Oceanography. The bad news is that since those measurements were made in the 1980s, the decline slowed in the 1990s, leaving present lead concentrations more than twice their preindustrial levels.

In a recent study, the first to document the decline in ocean lead over the past two decades, MIT professor of chemical oceanography Edward A. Boyle, provided scientific proof that lead in the ocean comes from people's use of substances such as leaded gasoline. Since unleaded gasoline was first introduced in the early 1980s, the use of leaded gas in the United States has dropped, hitting a low point at the end of the decade. "Europe began slowly phasing out leaded gasoline in the 1980s and mandated elimination in the 1990s, but we suspect a lot of the lead that is in the Atlantic Ocean now comes from high-temperature industrial activities. Activities such as smelting, coal combustion, and cement production may be the most recent culprits behind the residual lead in ocean surface water.

While researchers have argued for years that ocean-borne lead is tied to human activities because levels are highest in waters close to emission sources, there has been no data to definitively link the time dependence of the two. Metals such as aluminum have the same distribution patterns in our oceans but occur naturally. By understanding how trace metals in shells and sediments weave their way through moving water, researchers can use that knowledge as a tool to study how ocean circulation has changed over time.

By using the thermocline, as a sort of tape recorder, researchers can track water after it cools and sinks from the surface into the depths. This process can take a few years or many decades, so samples from different layers of water

document the movement of lead into the deep ocean over time.

The data show that lead levels peaked when the United States reported peak emissions, and dipped in the years following the phasing out of leaded gasoline. Even before Boyle collected samples of surface and subsurface seawater near Bermuda, a student provided him with a novel way to track Atlantic lead levels. Glen Shen, who received his doctorate from MIT in 1986, found that analyzing the composition of Bermudian coral, which grows a new layer each year like a tree adds a ring, provides an accurate record of its environment. The coral provides an environmental record that dates back to the 1880s. The effects of the Industrial Revolution in its layers can be seen, as well as the subsequent imposition of leaded gas, which was invented in the 1920s by the same person who invented freon. At the time, both were seen as great discoveries of modern science.

Lead from gasoline gets into seawater when lead in automobile exhaust attaches to fine particles in the atmosphere. About 10 percent of the particles, which include lead from the smokestacks of industrial countries, catch a ride on the wind to remote regions of the ocean and polar ice cores. While lead from industrialized countries moves all around the oceans, the Atlantic in particular receives lead from the United States on westerlies and from Europe on the trade winds. After it falls into surface ocean water, lead is converted into soluble form. It then falls to deeper water on sinking biological particles, such as fecal pellets. Lead remains in surface waters for about two years, and up to a few hundred years in deep water.

McArthur Takes Argonauts On Research Expedition

The NOAA ship *McArthur* took a contingent of its youngest scientists ever on a virtual field trip to California's Monterey Bay National Marine Sanctuary. These scientists are student "argonauts" with this year's JASON Project, *Oceans of Earth and Beyond.*

The JASON Project expedition, led by Dr. Robert Ballard, broadcasted to millions of students worldwide via satellite and the Internet. The expedition is part of the JASON Foundation for Education program to excite and engage students in science and technology, and provide professional development for their teachers through the use of advanced interactive telecommunications.

Former NOAA chief scientist and JASON host researcher Dr. Sylvia Earle joined the student argonauts aboard the *McArthur* as they conducted survey operations to examine the distribution of zooplankton in Monterey Bay.

For years the *McArthur* has welcomed teachers on board through NOAA's Teacher at Sea program. NOAA just began a demonstration project called Classroom@Sea where high school students can follow the *McArthur's* oceanographic research through an interactive web site. "With JASON, we can now take our outreach activities a step further to help students discover for themselves the excitement of hands-on research at sea. Hopefully, the experience will motivate some to go on to careers in science and technology," said Commanding Officer Lt.Cmdr, Bill Sites of the NOAA Corps.

ODP Pursues History Of Antarctic Ice Sheet

The Ocean Drilling Program (ODP) is conducting a two-month expedition near the edge of the antarctic continent, the first of a series to probe the historical development of the antarctic ice sheet and its consequences for Earth's climate.

The antarctic ice sheet, the world's largest, is 35 million years old and has waxed and waned through glacial cycles. "The ice sheets in the Northern Hemisphere are relatively young (about 3 million years old)," said Dr. Peter F. Barker, British Antarctic Survey and co-chief scientist. The waxing and waning of the Northern Hemisphere ice sheets changed sea level by about 110 meters. ODP program results show that these ice sheets are very sensitive to climate change. The expedition should help to answer the question, "How sensitive was the antarctic ice sheet?"

The answer to this question will help to understand how climate change works and therefore enable better decision making in regard to decisions affecting climate change. "Of particular importance is how quickly do various parts of the system respond, and therefore we must understand the history of antarctic ice," said Barker.

Ice sheets grow from accumulation of snow on top. Growth is balanced by drainage—by rapid ice flow in narrow channels. Here the ice is not frozen to the underlying rock, but is lubricated by unsorted wet sediment called till. The till is carried by the ice streams to the ice sheet edge and deposited there as the ice breaks off. Till deposits on the antarctic margin contain a record of past behavior of the ice sheet. /st/

Marine Resources

National Academy of Sciences Endorses Tough Restrictions

Federal studies describing recent Northeastern groundfish stock declines are sound, says the National Academy of Science (NAS) through an independent panel of experts in a recent report. Further, the panel finds "no scientific basis to support assertions that the regulations imposed by Amendment 7 of the Northeast Multispecies Management Plan are too severe from a biological perspective." The panel also supports the dramatic actions that have been taken to attempt recovery of these stocks.

Dr. Michael P. Sissenwine, NMFS science and research director of the Northeast, says his assessment scientists are gratified by the report. "The panel's members are all highly respected assessment scientists and we appreciate their exhaustive review," he said. "They have agreed with us that there's no escaping the need for restrictions on fishing effort if we want to protect stocks poised for recovery like those of Georges Bank, as well as those still in collapse, such as Gulf of Maine cod."

Shrimpers Can Use New Design Soft TED to Protect Sea Turtles

A new, soft turtle excluder device (TED), designed to allow threatened and endangered sea turtles to safely escape shrimp fishermen's nets while providing an additional option to shrimpers, has been approved for an 18-month trial period by the National Marine Fisheries Service, according to NOAA officials. This interim rule allows shrimpers the option of immediately using a new soft TED design—the Parker soft TED.

Previously approved soft TEDs were disallowed in areas of high sea turtle abundance off the coasts of Texas, Louisiana, Georgia, and South Carolina on March 1, 1997, and were disallowed throughout the rest of the southeast region on December 19, 1997. The action was taken because of an increased occurrence of sea turtle strandings attributable in part to soft TED use in these areas. The Parker soft TED does not use the slack, large mesh webbing that is known to cause turtle entanglements in previously approved soft TEDs. Instead, the Parker soft TED consists of a single triangular panel, composed of webbing of two different mesh sizes, that forms a barrier for turtles inside a trawl and that angles toward an escape opening in the top of the trawl.

The Parker soft TED was tested in a variety of trawl sizes and styles. During testing, the TED successfully excluded 100 percent of the turtles introduced into the trawl and is especially adaptable under certain environmental conditions; shrimp loss was approximately 9 percent. The Parker TED will be approved for permanent use only if the enforcement and observer data verify the effectiveness and correct use of this TED under commercial fishing conditions.

Blue Crab Education Project Funded by Virginia Sea Grant

It's considered a delicacy around this part of the Eastern Seaboard at least. And blue crab fisheries tap into that multimillion-dollar market. Now a

project to bring scientific information about the tasty critters to the public has started with two years of funding from the Virginia Sea Grant College Program.

A project to bring scientific information about blue crabs to the public has begun with two years of funding from the Virginia Sea Grant College Program. The project's main objective will be to inform educators, resource managers, commercial fishers, and the public about the blue crabs' ecology and detailed life history. Jacques van Montfrans, a Virginia Institute of Marine Science crustacean ecologist, and Vicki Clark, a marine education specialist in the Virginia Sea Grant Marine Advisory Program at VIMS, have developed the program in response to recent public concern about declines in the blue crab population in Chesapeake Bay.

The blue crab constitutes a popular symbol for the mid-Atlantic region. Blue crabs remain a viable fishery in the Bay and have historically accounted for more than half of the national blue crab harvest. Recently, however, high harvest levels in the neighboring state of North Carolina have rivaled the numbers of both Maryland and Virginia.

Although the blue crab is a well-recognized species contributing more than $260 million annually to Virginia's economy, many are not aware of some of the basic life history characteristics and ecological relationships that have been revealed to scientists over the past two decades. Van Montfrans and Clark hope to increase public understanding of the blue crab's development, nursery habitat requirements, its ecological role, and the fisheries management issues that affect the commercial as well as the recreational harvest. For more information about the blue crab project, contact Clark or von Montfrans at (804) 684-7000 or write to Vicki Clark, P.O. Box 1346, Sea Grant Marine Advisory Program, VIMS, Gloucester Point, VA 23062.

Sizes, Monitoring Needs For Atlantic Billfish Established

The National Marine Fisheries Service has established new minimum sizes for Atlantic blue marlin and Atlantic white marlin—two species of billfish—as part of an international commitment to reduce marlin landings by at least 25 percent, a NOAA spokeswoman said. The 1997 recommendation by the International Commission for the Conservation of Atlantic Tunas (ICCAT), the body that recommends international fishery management measures for member countries, also is calling for improvements in current billfish monitoring, data collection, and reporting procedures.

The billfish species are highly migratory and are subject to fishing pressure from many nations. NMFS works with other members of ICCAT to implement international conservation and management measures for these species.

Atlantic blue marlin and white marlin were identified as overfished by the Fisheries Service in September 1997. Atlantic blue marlin and white marlin stocks are estimated to be at 24 percent and 23 percent, respectively, of the biomass levels needed for maximum sustainable yield. Fishery managers are developing an amendment to the Billfish Fishery Management Plan with the help of a citizen's advisory panel to implement a rebuilding program for these species. The rebuilding program will include additional conservation and management measures for all Atlantic billfish to meet requirements of the recently amended Magnuson-Stevens Fishery Conservation & Management Act. /st/

Navy Currents

Deputy Chief of ONR Dr. Saalfeld Honored

Dr. Fred E. Saalfeld, deputy Chief of Naval Research and technical director of the Office of Naval Research since 1993, was presented with the Department of the Navy Distinguished Civilian Service Award by RAdm. Paul G. Gaffney, chief of naval research.

Gaffney said, "His inspired technical decisions have led to a generation of advanced capabilities for the 'Navy-after-Next.' Saalfeld has had a profound influence on the future of our national defense."

Saalfeld reinvented ONR into the government's first integrated science and technology (S&T) organization, capable of systematical management of a technology from earliest concepts to manufacturing technologies. This reinvented organization enables the Navy to leverage its relatively small investment to focus national S&T efforts.

Saalfeld manages all appropriated funding for basic research, applied research, advanced technology development, small business innovative research, and manufacturing technology. He also provides oversight of the Naval Research Laboratory, foreign liaison offices in London and Tokyo, and acquisition offices in Boston, Atlanta, Chicago, Seattle, and San Diego.

Saalfeld has taken the DOD lead to increase the participation of minorities, women, and people with disabilities in the sciences and engineering. ONR twice won the Nathanial Stinson Award (the only Navy organization to so) which is the Navy's highest award for achievement in equal employment opportunity and affirmative action.

Raytheon to Supply Mk 46 Torpedoes

The U.S. Naval Sea Systems Command has awarded Raytheon Systems Co. (Lexington, Massachusetts) a $31 million foreign military sales production contract to supply Mk 46 torpedoes to two international navies. The contract calls for 110 Mk 46 Mod 5 torpedoes and the upgrade of 20 Mk 46 torpedoes to the Mod 5 configuration. Raytheon expects the U.S. Navy to exercise a contract option to build an additional 72 Mk 46 Mod 5 torpedoes for a third navy—increasing the total contract award to $49 million.

The Mk 46 torpedo is the only lightweight torpedo in the world that has been in continuous production since 1965. Launched from surface ships and aircraft, the high-speed Mk 46 is effective in both deep and shallow water. Raytheon's torpedo facility at Mukilteo, Washington has produced more than 25,000 Mk 46 torpedoes.

Recent U.S. Navy decisions to transfer surplus ships to allied navies is having a very positive effect on Raytheon's business. In addition to supplying weapon systems to U.S. platforms acquired by allies, Raytheon is expanding the Mk 46 shipboard launch capability to accommodate fleets that are retrofitting their own ships and air ASW platforms. International navies will be able to launch the Mk 46 from the MILAS shipboard torpedo launcher.

GIE MILAS, a joint venture company formed by MATRA BAe Dynamics (France) and Alenia Difesa (Italy), originally designed, developed and built the MILAS system

to launch the MU 90 Franco-Italian torpedo. GIE MILAS is pursuing the adaptation of the Mk 46 torpedo into the MILAS ASW Missile System to offer the system as a stand-off ASW weapon systems capability to the 24 navies that carry the MK 46 torpedo. Raytheon signed a $1.7 million engineering development contract in October 1997 with GIE MILAS to support the integration of the Mk 46 torpedo into their system. Work is expected to be completed by 2000.

The U.S. Navy's ASW Rocket (ASROC) and vertical launch ASROC (VLA) launch systems have been certified to launch the Mk 46 Mod 5 torpedo. Both systems are limited to installation during ship construction or a major overhaul. In contrast, the MILAS launcher system is a cost-effective retrofit option for ships that require the installation of a shipboard torpedo launcher without a major overhaul.

Fiber-Reinforced Polymer Composites Upgrade Navy Pier

The Naval Facilities Engineering Service Center (NFESC), Port Hueneme, California is using fiber-reinforced polymer (FRP) composites to increase the strength of existing Navy piers. By using FRP reinforcement, many piers won't have to be rebuilt or replaced, and can often remain in service as upgrades are applied. Shore facility managers had to develop another way to extend the useful life of existing pier assets. Pier 11 at Naval Station Norfolk (Virginia) demonstrated feasibility. The 14-year-old, reinforced concrete structure, which berths nuclear-powered aircraft carriers, is heavily trafficked by large trucks and other vehicles.

When built, the pier was rated for 70-ton truck-mounted cranes. However, operators discovered that five longer deck spans of the pier had design shortfalls that limited 70-ton crane service to less than optimal capacity—thereby hobbling fleet operations. To address the shortfall, one of the five spans was chosen for the upgrade demonstration.

NFESC engineers designed a carbon-graphite, composite-laminate upgrade to increase the deck strength by 10 percent—increases of more than 40 percent have been demonstrated. The upgrade was designed to allow unlimited 70-ton and limited 90-ton service. Two upgrade areas of 19 feet, 2 inches by 15 feet, 11 inches were located adjacent to the curbs and outboard of the utility trenches. The upgrade consisted of adding external, biaxial reinforcing on the underside of the deck.

The form marks and surface discontinuities were knocked down by removing concrete with a small, compressed-air-driven hammer. The concrete surface was ground smooth and cleaned by sand blasting. Workers then applied an epoxy primer to the concrete and allowed it to cure. The composite consisted of uniaxial carbon graphite fiber sheets and epoxy resin matrix (saturant). The laminate was hand laid and cured without the aid of external heating or vacuum bags. The pier remained in service during installation.

Post installation tests indicated that the composite laminate was acting integrally with the reinforced concrete. The measurements indicated that stresses in the laminate and steel reinforcing bars would be well within allowable limits.

The Center for Intelligent Materials Systems and Structures (CIMS) at Virginia Polytech Institute and State University developed piezoelectric patches to monitor the long-term performance of the upgrade.

Graphite composite laminating costs about $150/pound or $82/square yard. Installation time is fast—labor costs are estimated at less than $55/square yard. (From *Navy Civil Engineer,* Winter 1997/1998). */st/*

International

Valeport Introduces New Instruments At Oceanology International Show

Valeport Ltd. (Dartmouth, Devon, U.K.) introduced several new products that had not been seen at the show before. The model 730 seabed-mounted Wave & Tide Gauge was developed in close co-operation with the University of Plymouth and boasts more features than any other pressure-based wave recorder currently available, including on board spectral analysis of data, tidal slope correction, choice of sampling regimes, and storm trigger options. The gauge is fully programmable using Valeport's WaveLog software, and the system can be used to provide recorded or real time tide and wave data.

Making its first appearance was the latest addition to the pressure-based water level and wave monitoring family. The Water Level Recorder (model VLR740) is a small titanium-housed portable pressure transducer easily installed and requires minimum maintenance. With a 128kbyte memory, the surface logger allows more than 65,000 data points; 800 days sampling at 20-minute bursts. The unit is particularly suitable for survey, water, and dredging companies that need water level and tide gauge recordings.

Valeport's model 604 self-recording/direct-reading CTD is the latest addition in a range of Series 600 CTDs. The predecessors to the 604 are more commonly known throughout the seismic and survey industries as "The Valeport." The new system provides accurate conductivity, temperature, depth, density, salinity, and speed of sound readings to a depth of 3000 meters and is compatible with Valeport's Datalog™ Windows®-based user software. The new "Valeport" is ideal for profiling and fixed mooring installation. The Model 808 self-recording/direct-reading electromagnetic current meter is a solid-state instrument that can store and output vector-averaged current data direct to Valeport Datalog software.

Sonardyne SIPS Targeted for Chinese Geophysical Ship *Nan Hai 502*

Sonardyne Asia Pte. Ltd. (Yately, Hampshire, U.K.) reports the firm has successfully commissioned a seismic integrated positioning system (SIPS) for installation onboard the *Nan Hai 502* survey vessel owned and operated by the China Offshore Geophysical Corporation (COGC). Although SIPS has been installed on 80 percent of the world's 3-D seismic fleet, the order is significant as it represents the first direct sale into the People's Republic of China of a Sonardyne SIPS system.

The installation of the system represents completion of a program to upgrade the *Nan Hai 502* from 2-D to 3-D capability. With a pair of 1,500-meter-long streamers, the vessel will immediately commence work in the shallow waters of the Bo Hai Sea off the coast of Eastern China. Sonardyne's Singapore office will provide crew training and technical support for the system.Positioning the streamers is well within the SIPS capability, which system was originally designed to meet requirements of dual streamers of 3,000 meters or less. Since then, dual and triple vessels have become operational with steamer lengths of 6,000 meters or better and the number of streamers being towed has increased from two to six.

MiniBAT Towed Body 'Instrumental' in Runoff, Coastal Saltwater Mixing Research

Coastlines in the United States have recently suffered extremely high rainfall due to the El Niño phenomenon. Studies by East and West Coast research institutes are now underway to determine the long-term problems this extraordinary amount of rainfall will cause to the fisheries industries. Of equal importance is the need for research to determine the after-effects reflected in various types of pollution problems.

Guildline Instruments' MiniBAT® is currently being used to assist in this research. It has been designed to be a workhorse for almost any instrumentation you might wish to tow whilst profiling. The system consists of the tow body itself, manual flight-control box, winch, eight- to 10-conductor slip ring, seven-conductor cable, and autopilot software. Three of the conductors are used to fly the MiniBAT with another four available for use with user-instrumentation.

The system used by the University of California/Los Angeles to study the "Fresh Water Bulge" employs an Applied Microsystems Ltd. and Sea Tech fluorometer. Another study, at Rutgers University, Institute of Marine & Coastal Sciences, uses a MiniBAT with a SeaBird Seacat19 CTD attached. The MiniBAT system is one of a suite of instruments being used by Rutgers at its Long-Term Ecosystem Observatory (LEO-15) to study upwelling events in 15 meters of water off the New Jersey coast. The undulating CTD surveys provide higher resolution coverage of the upwelling region than is achievable by discrete CTD casts. This results in less ship time with overall cost-saving benefits.

Previously, researchers believed that there was a single upwelled bulge of cold water in the center of an upwelling feature. However, sampling over the past five years has shown that the subsurface water structure is much more complex. Instead of one bulge of cold water, the coldest upwelled water is split into one intrusion along the offshore front and a second along the shore. Also, isotherms near the center of the patch of cold surface water are depressed. Researchers said the added resolution provided by the undulating MiniBAT has allowed better observation of the complexity of the subsurface water structure.

MacArtney Wins Umbilical Winch Order from Stolt Comex Seaway

A spokesman for MacArtney A/S (Esbjerg, Denmark) announced the recent award of a contract from the Stolt Comex Seaway Group for 11 deep water ROV winches. The 12-ton SWL electro-hydraulic umbilical lift winches, which include Focal Technology Inc. electro-optic slip rings, 3,000-meter umbilical tension spooling, and terminations are being manufactured, in cooperation with MacArtney, by the Esbjerg-based engineering and manufacturing company Norlau.

The winches are being produced in conjunction with an Stolt Comex build program of its new work-class ROV systems scheduled for operation in deep development oilfields. The tight delivery schedule is being followed mainly due to level of cooperation between the customer, the system supplier, and its sub contractors.

Leica Supplies Reference Stations, Navigators for DGPS Service in U.K.

Svitzer Ltd. (Great Yarmouth, U.K.) has selected Leica Geosystems Inc. to supply high-precision differential GPS equipment for its long-range radio-link DGPS service in the North Sea and Irish Sea. Pat O'Grady, navigation sales manager for Svitzer, said "We selected the Leica MX 9400R for all of our reference stations in the North Sea after carrying out comparison trials with other makes of GPS receiver." Currently, there are four reference stations at east coast locations in the United Kingdom, ranging from the Shetland Islands to the county of Norfolk in southeast England. There is another reference station on the Isle of Man to cover the Irish Sea.

"The MX 9400R is a recent-technology 12-channel receiver that utilizes choke ring antennas, achieving high accuracy with excellent multipath rejection. The differential data output is in the standard RTCM SC 104-2 format, which is usable by most other types of GPS receivers," O'Grady said. The Svitzer DGPS service currently uses HF/MF frequencies in the 1.8-2.1 MHz band to transmit DGPS correction data from the reference stations. The 100-watt groundwave signals are modulated at 300 baud FSK and they provide survey quality DGPS corrections up to a typical range of 500 kilometers from the transmitters.

In addition to fixed DGPS integrity monitors at Great Yarmouth and Aberdeen, Svitzer has established two remote monitor stations to receive correction signals from the more distant reference stations.

The Svitzer DGPS positioning service is used for a variety of applications—including deep seismic surveys, rig site and shallow gas surveys, rig positioning and drilling support, pipeline and cable route surveys, construction support, underwater inspection surveys, environmental surveys, and monitoring of floating production facilities. */st/*

Ocean Business

EPC Labs 'Turns Tables,' Sells Recorders to Japan

Danvers, Massachusetts-based EPC Labs Inc. reported recently that the firm's Japanese sales representative Toyo Corp. sold two model 9802 thermal graphic recorders to the Japanese Defense Agency; one model 9802 and one model GSP-1085-0 to the Hydrographic Department of the Japan Maritime Safety Agency (JAMSTEC); and two model ADS-640 acquisition display systems to the Geological Survey of Japan.

EPC marketing manager Ted Curley said the two TGRs for the Defense Agency are for use with multibeam echosounders aboard two different vessels. Another 9802 TGR and a GSP-1 086 for JAMSTEC will be all-purpose units. The two ADS-640s will be used to replace old echosounders and will incorporate a key-gate program and external monitor function for its deep water application.

RD Instruments Opens East Coast Sales Office

RD Instruments (San Diego, California) recently announced the opening of an East Coast sales office in North Falmouth, Massachusetts. The new office address is RD Instruments-East, P.O. Box 1870, North Falmouth, MA 02556; (508) 563-5282, fax at (508) 563-5184. A spokeswoman said the office is under the direction of Earl Childress who will focus on expanding RDI's sales in the region.

URI Ocean Technology Center Awards Grant for New Sonar

University of Rhode Island's Ocean Technology Center, a Research Center of Excellence, recently awarded a $70,0000 grant to Pyrcon LLC (Kingston, Rhode Island) through the university's Ocean Technology Industry Development Grant Program. Pyrcon is a small company specializing in underwater acoustic systems. Funding for the program is provided through a block grant from the Rhode Island Economic Policy Council. URI ocean engineering professor James Miller told *Sea Technology* the new sonar, developed especially for commercial and high-end recreational vessels, will be capable of detecting large rocks and whales.

Major partners with Pyrcon in the project are the Naval Undersea Warfare Center (Newport, Rhode Island), the Navy's foremost sonar development laboratory, and Northstar Technologies (Acton, Massachusetts), a leading provider of global positioning systems (GPS) for marine and aviation applications.

Miller, president and founder of Pyrcon, expects the sonar—named AWARE—to be able to detect large rocks and similar hazards hundreds of yards ahead of a ship, enabling it to avoid grounding in shallow water. A vessel equipped with AWARE will also be able to avoid collisions with floating objects or submerged objects near the water's surface that cannot be detected visually or by radar. Such a system may prove useful in reducing collisions between large whales and large ships.

He said there was evidence that the blue whale found off Narragansett Bay recently had collided with a ship, although it is still uncertain whether this was the cause of death. However, ship strikes are a significant source of

human-caused death among rare and endangered large whales along the U.S. East Coast.

Other grants awarded this year by URI's center include $70,000 to SubChem Systems Inc. (Jamestown, Rhode Island) to continue development of a submersible chemical analyzer for water monitoring. Another $34,000 goes to VG SeaFarms LLC (Wakefield, Rhode Island) to expand the capabilities of its plant to culture tautog, a relatively new species being considered for aquaculture.

Odom Echoscan Sounder To Panama Canal Commission

Odom Hydrographic Systems Inc. (Baton Rouge, Louisiana) announced the recent sale of an Echoscan multibeam sounder to the Panama Canal Commission. Odom personnel spent a week in Panama installing the equipment and providing training for the commission's Engineering Division Surveys Branch, according to a spokeswoman.

In another sale, Jurukur Teguh, a private company in Malaysia, just purchased an Echoscan as part of a complete suite of equipment. Personnel from that firm traveled to Odom's facility in Baton Rouge for several days of training aboard the company's specialized demonstration vessel.

U.S. Army Corps of Engineers districts are stocking up on the system as well. In addition to a previous sale of two units to the Galveston District, the Baltimore District has just purchased an Echoscan and Odom personnel will provide on-site training.

Pioneering Marine Biologist Earle is 1998 National Geographic Explorer-in-Residence

Marine biologist/algalogist Dr. Sylvia A. Earle—sometimes known as "Her Royal Deepness," a term coined in Editor David Graham's *Sea Technology* profile of her in February 1987—is the 1998 explorer-in-residence at the National Geographic Society. She is working with a variety of society divisions on projects involving oceans.

Earle, who will be 63 in August, has pioneered research on the ecology of marine ecosystems and has led more than 50 expeditions, amounting to 6,000 hours logged underwater. She also holds numerous diving records, including several to depths of 3,000 feet in the one-person submersible *Deep Rover*. Former chief scientist for NOAA, Earle is founder and chairman of Deep Ocean Exploration & Research Inc. (Oakland, California), co-founder of Deep Ocean Engineering Inc. (San Leandro, California), and spokesman for SeaWeb, a conservation initiative of the Pew Charitable Trusts. She is

author of more than 100 scientific and popular publications, including the 1995 book, *Sea Change*. Her research places special emphasis on marine plants and the development of technology for access and research in the deep sea.

She follows two other explorers-in-residence: polar explorer Will Steger (1996) and high-altitude archaeologist Johan Reinhard (1997). The honoree works at the society's Washington, D.C., headquarters on scientific research projects, exhibits, lectures, magazine and television projects, and books, as well as some exploration under the society's banner.

KMI To Hold Conference in Portugal About Undersea Fiberoptics Markets

KMI Corp. (Newport, Rhode Island) announcd it will sponser an international conference in June. The "4th Fiberoptic Submarine Systems Symposium" will focus on worldwide undersea fiberoptics markets, according to KMI president John Kessler. The theme, he told *Sea Technology*, will be "When Will Capacity Catch Up to Demand?" The conference is slated for June 16-18 at the Hotel Palacio in Estoril, Portugal.

He said the need is critical for understanding this market characterized by "the explosive growth of the Internet and broadband transmission, as well as the potential for saturation and over-deployment.

Kessler, who also chairs the symposium, said new technologies such as wavelength add/drop and fiber and channel add/drop, new branching techniques, and high-fiber-count cables will expand the flexibility and access of domestic and transoceanic communications while keeping costs relatively flat.

For further information or a conference program, contact Kessler at KMI Corp., America's Cup Ave. at 31 Bridge St., Newport, RI 02840; (800) 343-4035, fax at (401) 847-5866, e-mail: kmi@ids.net.

PSI Wins Automated Sound Velocity Profiling Contract

Physical Sciences Inc. (PSI) of Andover, Massachusetts, has been awarded a research contract from the Naval Undersea Warfare Center, Newport, Rhode Island, to develop an automated sound velocity profiling system. General Dynamics Advanced Technology Systems Inc., Greensboro, North Carolina, and Whippany, New Jersey, is the subcontractor on this effort.

According to PSI's Dr. Peter E. Nebolsine, the firm is developing an automated system for near-surface, real-time, remote sound velocity profiler to measure the velocity of a transmitted acoustic pulse as a function of depth. The implemented system will allow a significant enhancement of tactical active sonar system performance due to accurate minute-to-minute updates of the local sound velocity profile.

Implementation of a laser doppler sound velocity profiler will enable the optimization of active sonar performance on surface combatants to maximize detection ranges and search rates by environmental adaptation in the highly variable, adverse, shallow-water environments of littoral areas. Commercial application of the system is anticipated for oil exploration and the signal processing approach can be extended to other LIDAR-based sensing systems that require accurate ranging in the presence of confounding returns. /st/

Meetings

JUNE

June 1-3, 1998—54th Annual Institute of Navigation Meeting, Denver, Colorado. Information: Lisa Beaty, Institute of Navigation, 1800 Diagonal Rd., Suite 480, Alexandria, VA 22314; (703) 683-7101.

June 1-4, 1998—Coastal & Marginal Seas, Paris. Information: Judi Rhodes, The Oceanography Society, 4052 Timber Ridge Dr., Virginia Beach, VA 23544; (757) 464-0131.

June 2-5, 1998—5th International Caspian Oil & Gas Exhibition & Conference, Baku, Republic of Azerbaijan. Information: Susan Crouch, Spearhead Exhibitions Ltd., Ocean House, 50 Kingston Rd., New Malden, Surrey KT3 3LZ, U.K.; +44 (181) 949 9222, e-mail caspian@spearhead.co.uk.

June 6-8, 1998—AUVSI 98, Huntsville, Alabama. Information: Association for Unmanned Vehicle Systems International, 1200 19th St. NW, Suite 300, Washington, DC 20036; (202) 857-1889.

June 7-10, 1998—International Conference on Health, Safety & Environment, Caracas, Venezuela. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393.

June 9-11, 1998—Department of Defense-Industry Aerospace Coatings Conference, Atlanta. Information: Omar Deel, Battelle Communications Dept., 505 King Ave., Columbus, OH 43201; (614) 424-4405.

June 15-18, 1998—11th Latin American Petroleum Show, Maracaibo, Venezuela. Information: International Exhibitions Inc., 1635 West Alabama, Houston, TX 77066; (713) 529-1616.

June 15-19, 1998—PACON 98, Seoul, South Korea. Information: PACON International, P.O. Box 11568, Honolulu, HI 96828; (808) 956-6163.

June 16-18, 1998—Sea+Work 98, Southampton, U.K. Information: Sea+Work 98 Secretariat, The Old Mill, Lower Quay, Fareham, Hampshire PO16 0RA, U.K.; +44 (1329) 825 335.

June 22-23, 1998—1998 API Tanker Conference, La Jolla, California. Information: Allie Chamberlain, American Petroleum Institute, 1220 L St. NW, Washington, DC 20005; (202) 682-8229, e-mail chamberlaina@api.org.

June 23-25, 1998—UDT Europe 98, London. Information: Sally Towner, Undersea Defence Technology Europe 98, Nexus Information Technology, Nexus House, Swanley, Kent BR8 8HY, U.K.; +44 (1332) 660 070.

June 24-28, 1998—24th Annual National Weather Service Reunion, Point Vedra Beach, Florida. Information: Jerry Struck, National Weather Service Association, 3450 Peoria Rd., Orange Park, FL 32065; (904) 269-3840.

June 28-July 2, 1998—15th World Dredging Congress, Las Vegas, Nevada. Information: World Dredging Association, Exhibits Director, P.O. Box 5797, Vancouver, WA 98668; (360) 750-0209.

June 30-July 1, 1998—Condition-Based Maintenance Symposium, Arlington, Virginia. Information: Sally Cook, Meetings Manager, American Society of Naval Engineers, 1452 Duke St., Alexandria, VA 22134; (703) 836-6727.

JULY

July 5-10, 1998—Optimization of Production Systems Forum, Breckenridge, Colorado. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393.

July 5-10, 1998—Fluid Applications in Drilling & Completing High Angle & Horizontal Wells, Breckenridge, Colorado. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393.

July 6-8, 1998—Geographical Information Systems for the 21st Century, Udine, Italy. Information: Liz Kerr, Conference Secretariat, GIS 98, Wessex Institute of Technology, Ashurst

Lodge, Ashurst, Southampton SO40 7AA, U.K.; +44 (1703) 292 853.

July 8-10, 1998—Eurock, Trondheim, Norway. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393

July 12-17, 1998—Hydraulic Fracture Diagnostic Methods Forum, Breckenridge, Colorado. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393

July 12-17, 1998—Achieving Coherent Reservoir Descriptions from the Micro-Scale to the Meso-Scale Forum, Breckenridge, Colorado. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393

July 19-24, 1998—SEG/SPE Forum, Big Sky, Montana. Information: Dan Lipsher, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083; (972) 952-9393

July 25-28, 1998—Shiport China 98, Hong Kong. Information: Business & Industrial Trade Fair Ltd., Unit 1223, 12/F Hong Kong International Trade & Exhibition Centre, 1 Trademart Dr., Kowloon Bay, Hong Kong; (852) 2865 2633.

July 29-31, 1998—Oil Spill 98, Southampton, U.K. Information: Helen Fisher, Oil Spill 98 Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, U.K.; +44 (1703) 293 223.

AUGUST

August 7-11, 1998—Order for the Oceans at the Turn of the Century, Oslo, Norway. Information: Snorre Fjeldstad, Conference Secretary, The Fridtjof Nansen Institute, P.O. Box 326, N-1324 Lysaker, Norway; +47 (67) 11 19 00, e-mail conference@fni.no.

August 10-13, 1998—8th Stockholm Water Symposium, Stockholm, Sweden. Information: Symposium Secretariat, Stockholm Water Symposium, SE-106 36 Stockholm, Sweden; +46 (8) 736 20 21.

August 17-21, 1998—EXPO 98, International Year of the Ocean, Lisbon, Portugal. Information: Dr. David Halpern, MS 300-323, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; e-mail halpern@pacific.jpl.nasa.gov.

August 20-21, 1998—AUV 98, Cambridge, Massachusetts. Information: Claude P. Brancart, President, IEEE/OES, c/o Draper Laboratory (MS 55), 555 Technology Square, Cambridge, MA 02139; (617) 258-3097, e-mail c.brancart@ieee.org.

August 23-28, 1998—6th International Conference on Paleoceanography, Lisbon, Portugal. Information: Fatima Abrantes, Associaçao Portuguesa de Paleoceanografia, Apartado 7618 Alfragide, 2700 Amadora; +351 (1) 346 39 15.

August 25-28, 1998—Offshore Northern Seas Conference & Exhibition, Stavanger, Norway. Information: ONS, P.O. Box 410, N-4001 Stavanger, Norway; +47 (51) 59 81 00.

SEPTEMBER

September 9-12, 1998—ITEP China 98, Beijing, China. Information: Michael Dreyer, Managing Director, Hannover Fairs Asia Pte. Ltd., 84 Amoy St., 3rd Floor, Singapore 069903; (65) 220 7633.

September 13-18, 1998—SEG International Exposition & 68th Annual Meeting, New Orleans. Information: Society of Exploration Geophysicists, 8801 S. Yale, Tulsa, OK 74317; (918) 497-5500.

September 14-16, 1998—Fundamentals of Corrosion and its Control, Wrightsville Beach, North Carolina. Information: S. Darden, LaQue Corrosion Services, P.O. Box 656, Wrightsville Beach, NC 28480; (910) 256-2271, e-mail info@laque.com.

September 15-18, 1998—ION-GPS 98, Nashville, Tennessee. Information: Lisa Beaty, ION National Office, 1800 Diagonal Rd., Suite 480, Alexandria, VA 22314; (703) 638-7101.

September 16-18, 1998—SEAMER 1998, Paris-Porte de Versailles, France. Information: Lou Scanlon at (410) 949-6461 or Pierre Wagner, SEAMER-USA, 26 Windward Dr., Serverna Park, MD 21146; (410) 544-2405, fax (410) 315-9082. /st/

Contracts

TDI Halter, Sabine Pass, Texas, $30 million contract for building three cantilever drilling and integrated servicing barges for future operation in Lake Maracaibo offshore Venezuela. (Sedco Forex, Montrouge Cedex, France)

Newpark Marine Fabricators, Galveston, Texas, contract (terms not disclosed) to upgrade the semisubmersible drilling rig Omega for drilling a well for EEX in the deep water Garden Banks area. (Sedco Forex, Montrouge Cedex, France)

Friede Goldman International Inc., Jackson, Miss., contract (terms not disclosed) to convert the submersible drilling rig Max Smith to an EVA-4000 design semi with work starting June 1998. (Noble Drilling, Houston)

Edison Chouest Offshore, Galliano, La., contract (terms not disclosed) to sell the 240-foot dynamically positioned diving support vessel *Laney Chouest.* (American Oilfield Divers, Lafayette, La.)

Global Marine Inc., Houston, $150 million contract to purchase a third-generation semisubmersible drilling rig, the Stena Forth, for operation in the North Sea. (Stenreoch Ltd., Aberdeen, Scotland)

Keppel FELS Shipyard, Singapore, $130 million contract for the fabrication of a new KFELS Mod V class harsh environment jackup suited for drilling in 300-foot waters. (Ensco International, Dallas, Texas)

Arab Heavy Industries, United Arab Emirates, contract (terms not disclosed) for four Searex-design work jackups that can perform heavy-lift, hookup, workover, coiled tubing, snubbing, accommodation, diving support, and drilling support services. (Bibby Line, London, U.K.)

Physical Sciences Inc., Andover, Mass., contract (terms not disclosed) to develop an automated sound velocity profiling system. This Laser Sound Velocity Profiler will measure the velocity of a transmitted acoustic pulse as a function of depth. (Naval Undersea Warfare Center, Newport, R.I.)

Oceaneering International Inc., Houston, turnkey contract (terms not disclosed) for the tieback of a subsea well in West Cameron Block 638 to a platform in West Cameron 648. Scope of work includes supply and installation of a coiled tubing flowline, control umbilical, flowline and umbilical risers, hydraulic control system, chemical injection skid, and related interface hookups. (Kerr-McGee Oil & Gas Corp., Houston)

Analysis & Technology Inc., North Stonington, Mass., $25 million contract continuation (potential value over five years) for engineering services to maintain combat support systems for submarines, surface ships, and shoreside installations. (Naval Surface Warfare Center, Carderock Div., Philadelphia, Pa.)

Analysis & Technology Inc., North Stonington, Mass., $15.7 million subcontract (potential value over five years) for engineering support on the New Attack Submarine Program. (EG&G Inc.)

Falmouth Scientific Inc., Cataumet, Mass., contract order (terms not disclosed) to provide 15 additional three-dimensional acoustic current meters and software for studying water exchange through the Fram Strait in the framework of the European Union program VEINS (Variability of the Exchange in the Northern Seas). (Alfred Wegener Institute)

Flotation Technologies Inc., Biddeford, Me., order (terms not disclosed) for six trawl-resistant bottom mounts (TRBM model DD-100) including RD Instruments' "Workhorse Sentinel" acoustic doppler current profilers. (Israel Oceanographic & Limnological Research Ltd.) */st/*

Books

The Geophysical Directory, 1998

Paperback. 532 pp. The Geophysical Directory Inc. $70

This 53rd edition is a vital record of companies worldwide that provides geophysical equipment, supplies, and services. Petroleum and mining companies and government agencies using geophysical techniques are also listed. The recognized source for information in this industry, the directory contains 7,115 worldwide companies and branch offices with names, addresses, and phone/fax numbers; some 18,580 personnel and titles; and a company cross-reference to trace mergers and buyouts since 1950. Published by the same organization since "volume one" in 1946, the directory is the industry's primary source. CIRCLE **No. 301**

Dynamics of Marine Sands
By Richard Soulsby

Hardbound. 250 pp. Thomas Telford Publishing. £50

Engineers and research academicians can find sediment movement in rivers, estuaries, and the sea of practical importance. Unfortunately, practical engineers looking for an urgent solution can often find results published in unfamiliar language in not-so-available journals and conference proceedings. Soulsby's book bridges the gap by summarizing research results in a unified form backed up by examples and case studies. Includes methods for calculating various hydrodynamic and sediment dynamic quantities for sediment transport applications. The book deals with coastal and offshore sea areas, rivers, and estuaries for sand and gravel sediments. CIRCLE **No. 302**

The Sacred Balance
By David Suzuki

Hardback. 272 pp. Prometheus Books. $25.95

Subtitled "Rediscovering Our Place in Nature" (with Amanda McConnell), the book is a call to consciousness. By continually abusing air, water, and environment, we threaten the lives of every species—including our own. We burn fossil fuels in quantities that add twice as much greenhouse gas as the planet can absorb; agricultural demands are depleting topsoil at the rate of 24 billion tons per year; more than two-thirds of forests have been invaded or cut down; and wetlands and coral reefs are under assault from pervasive toxic pollutants. CIRCLE **No. 303**

Lost Voyages
By Bradley Sheard

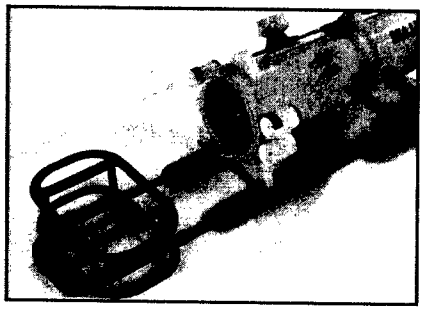
Softcover. 216 pp. AquaQuest Publications Inc. $29.95

Sheard looks at shipwrecks, most specifically at two centuries of shipwrecks in the approaches to New York. He notes the book is a story about oceangoing vessels, the tragedy of shipwrecks, and about the maritime history of the region. The book details the throes of howling winter nor'easters, frozen rigging, tremendous seas, collisions, burning oil, and exploding torpedoes. It is also about the evolution of ships and shipping. The author takes us into this world shut off to all but a few through hundreds of underwater and historical photographs, drawings of ships as they lie today, and a lively narrative. CIRCLE **No. 304**

Product Development

Boat Navigation Console
BNC-100 boat navigation console is designed for inflatables used by U.S. Navy SEALS and Special Forces teams worldwide; rugged console features knotmeter, Ritchie compass, cyclume light stick; equipped boat is easily navigated—even by dead reckoning—even at night. RJE International Inc. CIRCLE **No. 201**

Remote Control Metal Detector



RMD-1 remote metal detector is reasonably priced, high-tech underwater search gear; pulse inductor attaches to SeaOtter and SeaLion ROVs; locates and tracks underwater pipelines, missing tools & dredge parts, weapons and unexploded ordnance, lost treasure; can detect both ferrous and non-ferrous metal objects at depth while ignoring mineralization in the saltwater and seabed. J.W. Fishers Mfg. Inc. CIRCLE **No. 202**

Chirp Sub-Bottom Profiler
X-STAR Full Spectrum™ sub-bottom profiler for ROVs is powered by the ROV; data are sent on ROV umbilical via dedicated conductor or can be uplinked via Ethernet port; device transmits FM pulse that's linearly swept; applicable for geo-technical surveys, hazard surveys, site remediation, pipeline surveys, scour assessments. EdgeTech Inc. CIRCLE **No. 203**

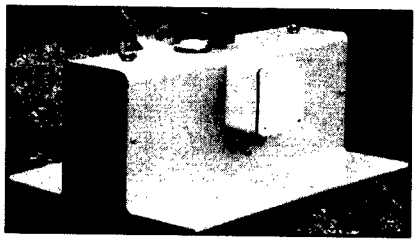
Latching Solenoid Valve
Small, lightweight valve was custom designed for use in battery powered hydraulic systems requiring low power consumption in small package; 2-way, 2-position latching valve; zero leakage; contamination-tolerant soft seats; operating pressure is 3,000 psid. Hydracon Co. Inc. CIRCLE **No. 204**

Redundant Sensor CTD
Idronaut Mk 317 is multiparameter CTD with closely spaced, very fast platinum resistance thermometer, 3-cm ceramic four-electrode conductivity cell; extremely low thermal mass and free-flushing, which eliminates need for pumps; redundant sensor capability; logging or direct reading available; WOCE specs. Cape Cod Instruments Inc. CIRCLE **No. 205**

New Millennium Watermaker
MiniPack™ 170 is new reverse osmosis, 12- or 24-volt desalinator; ideal for small power and sailboats; produces up to 170 gallons/day; compact, easy to use, moderately priced; new MiniPacks available in 110- or 220-volt AC open-frame or modular versions. HRO Systems Inc. CIRCLE **No. 206**

Ocean Depth Actuated Valve
Model 2800-100 pressure-operated valve is designed for battery powered hydraulic systems requiring zero leakage; designed for 1,300 psi actuation range; bubble tight closure; flow is 0.12" ESEOD; size 2.5" diameter x 5.15" long; weighs 3.1 lbs. Hydracon Co. Inc. CIRCLE **No. 207**

Tipping Bucket Flow Gauge



Model 6506 flow gauge measures small volumetric flows that exceed capacity of common rainfall gauges; measure flows up to 2 gallons/minute with resolution of 0.03 gallons; output signal is potential free switch closure; weatherproof construction; suitable for environmental monitoring at remote sites. Unidata America. CIRCLE **No. 208**

Acoustic Positioning Beacons
Comprehensive range of beacons instantly compatible with most tracking systems; 144 channel settings for operation with such USBL systems as Simrad HPR/HiPAP®, Sonardyne, ORE Trackpoint II/LXT; rotary on-off, frequency selection switches; receive frequency, 17-26 kHz; transmits (one burst) at 27-33 kHz; 100 dB re 1 µPa or better receive sensitivity. Applied Acoustic Engineering. CIRCLE **No. 209**

Low-Cost Professional Sonar
Model 595 side-scan sonar for ocean survey operations; configured with single frequency, stainless steel towfish; priced under $50,000; system offers professional level results and is supplied with 100-meter lightweight tow cable and 595 recorder; upgradeable to dual frequency by adding A/D converter, TVG PCBs, and purchasing dual-frequency 100/500 kHz towfish. Klein Associates Inc.
CIRCLE **No. 211**

Sealed Connector Line
Precision electronic connectors, available in sealed versions rated to IP68; series 102, 103, & 1031 available with up to 7-, 12-, and 19-gold-plated contacts, respectively; receptacles available with straight solder or crimp contacts; chrome-plated, machined-brass bodies withstand heavy use; for design flexibility, sealed connectors mate with unsealed versions. W.W. Fischer Inc. CIRCLE **No. 212**

Navigation Software
Visual Navigator™ and Visual GPS Planner™—components of Visual Navigation Suite™—are available separately; Navigator quilts and scrolls NOA charts oriented to match course; boat location is pinpointed and tracked with input from GPS receiver; real-time navigation instructions can be sent automatically to autopilot; Planner is electronic charting, planning software for home computers for setting waypoints and routes on digital charts. Nobeltec Corp.
CIRCLE **No. 214**

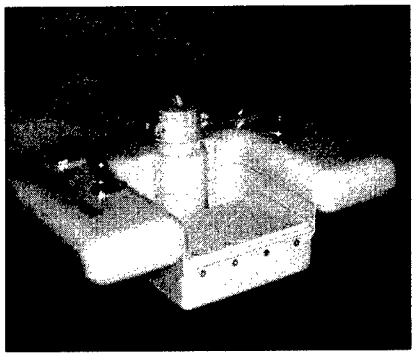
Inflatable Workboats
Inflatable hull, rigid deck boats are custom built for shallow water seismic exploration; 32-ft. River Freighter features two 3-ft.-dia. vulcanized Neoprene pontoons connected by 5086 marine alloy aluminum deck; transom carries two 50-hp Yamaha outboards; 17-ft. Mini Snout is hard-decked boat can carry up to eight people with one 50-hp outboard. Demaree Inflatable Boats Inc. CIRCLE **No. 213**

DGPS Navigator
Model GP35 differential GPS navigator provides precise position-fixing; internal receiver protected by a waterproof display designed to withstand harsh marine conditions; stores 1,000 points of ship track; 350 points for marks, 30 routes of up to 30 waypoints each; 4.4-inch LCD screen is bright, adjustable. Furuno U.S.A.
CIRCLE **No. 210**

Submarine & Dive Vehicle
Nautilus sport submarine cruises at 2-3 knots to safe operating depth of 100 feet; 10-ft. wet sub useful for fish watching, coral reef cruising; retails at $3495; "Tuna" diver propulsion vehicle carries divers effortlessly at 3-4 knots; aluminum DPV was tested to 180 feet; retails at $1600. Hydrodyne Marine Corp. CIRCLE **No. 216**

Water-Resistant Writing Paper
"Rite in the Rain" designed for working in marine environments; available in a variety of options: log books, notebooks, loose-leaf sheets, copier paper, custom-printed bid sheets, tags; durable and water-resistant. J.L. Darling Corp. CIRCLE **No. 217**

Calm Water Skimmer



"Skim-pak" model 2200-SH skimmer features increased performance by nearly twice with smaller profile; smallest open water skimmer produced by firm; extended skim range of 5-58 gallons/minute; weighs 7 lb.; intended for single-person attended use, skimmer has 1-1/2" ports top and bottom for use in tanks, sumps, lagoons, shallow water oil-spill cleanup. Douglas Engineering. CIRCLE **No. 215**

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People

Laughton

Teegardin

Sir Anthony Laughton has been elected president of the Hydrographic Society in succession to Ross Douglas, former Dominion Hydrographer of Canada. Laughton is chairman of two National Environmental Research Council steering and review groups and holds other oceanographic positions.

Underwater Engineering Services (Port St. Lucie, Florida) appointed **Wayne Teegardin** as manager of conventional diving services. He has extensive experience in operating commercial diving companies. **Noel Kutil** was promoted to manager of nuclear diving services and **Adam Litt** to operations manager.

Dr. Marcia K. McNutt, president and CEO of Monterey Bay Research Academy (MBARI), has been elected president of the American Geophysical Union (AGU).

Dr. William D. Phillips, a principal investigator of the Office of Naval Research, was a 1997 Nobel Laureate for the development of methods to cool and trap atoms with laser light. He shared the award with **Professor Steven Chu** (Stanford University) and **Professor Claude Cohen-Tannoudji** (Laboratoire de Physique de Ecole Normale, Superieure).

Helge Namtvedt Minken joined Aanderaa Instruments (Nesttun, Norway) as technical manager. He had been group leader, technology systems group, at Simrad Norge AS (Norway). Also **Tor Aamodt** joined the company as marketing manager. Aamodt had been sales manager for OCEANOR (Norway).

Kevin C. Peterson, former executive vice president and president of its intervention technologies group, became chief operating officer of American Oilfield Divers Inc. (Houston, Texas). */st/*

ST Looks Back

May Issue

25 Years Ago

1973. Global Marine Inc. received the Offshore Technology Conference Distinguished Achievement Award for operation of deepsea drillship *Glomar Challenger* in connection with the Deep Sea Drilling Project. The ship set records for operating continuously in a dynamically positioned mode, deepwater hole reentry, and drilling in more than 20,000 feet of water....Industry spokesmen projected that the North Sea would be producing 3 million barrels of oil/day by 1980 (three time that of the 1973 Gulf of Mexico production) and that $10 billion of equipment would be needed by the oil industry over the next 10 years.

15 Years Ago

1983. Sweden tightened rules for pursuit of alien submarines violating its territorial waters—in coastal waters, force of arms will be applied without warning; outside of that area, it will be preceded with a warning....Dr. Robert White, meteorologist, was elected president of the National Academy of Engineering....Joint Oceanographic Institutions Inc. selected Texas A&M University as the science operator of the Advanced Ocean Drilling Program, a 10-year, $30 million program, a follow-on to the Deep Sea Drilling Project. Drillships selected must be fully capable of utilizing a drill string up to 9,144 meters long.

10 Years Ago

1988. Shale J. Niskin, "dean of instrumentation developers" and founder and president of General Oceanics Inc., died. He founded the company while he was a research scientist at the University of Miami's Rosentiel School of Marine & Atmospheric Science....Foreign nations exporting yellowfin tuna to the United States were required to reduce the number of dolphins killed during purse seine fishing....Capt. James E. Koehr, head of the Naval Oceanography Command, was promoted to rear admiral, completing the upgrading of NavOceano....U.S. fisheries exports increased 22 percent over the previous year to $1.66 billion. However U.S. fish imports rose to $5.6 billion because the U.S industry could not meet the U.S. demand for products like lobster, tuna, shrimp, scallops, and farmed salmon. */st/*

OCEANOGRAPHIC TECHNICIAN

The *Cape Henlopen* is a general purpose coastal zone oceanographic research vessel operated by the University of Delaware.There currently is an opening for an oceanographic technician who is responsible for operating and maintaining the *Cape Henlopen*'s oceanographic instrumentation including CTD, rosette, and ADCP systems. The oceanographic technician is also responsible for sediment and biological sampling using corers, grabs and a variety of nets and acts as the ship's radiation safety officer. The position requires a Bachelor's degree in a field related to oceanography and two years' experience in oceanographic field operations including work on an oceanographic research vessel. Graduate studies may satisfy part of the experience requirement. Strong computer skills, including knowledge of basic scientific data processing techniques, are required. The physical ability to perform arduous work on deck under adverse environmental conditions is required. In addition to these requirements knowledge of electronics, C programming language, and Sea-Bird CTD systems are desired. The *Cape Henlopen* is normally at sea for 200 days per year and the oceanographic technician is expected to sail two-thirds of those days with individual deployments up to 21 days long. Send resume and three references to Timothy Pfeiffer, University of Delaware, Graduate College of Marine Studies, Lewes, DE 19958.

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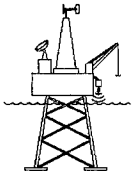

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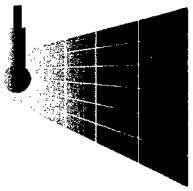

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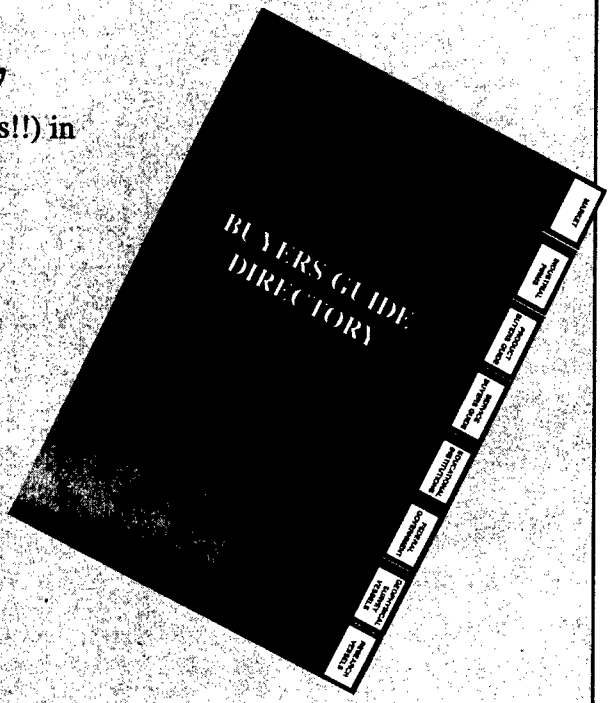

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Marine Entrepreneurs and Law of the Sea

Dr. Philomene A. Verlaan

Dr. Philomene A. Verlaan is an attorney and oceanographer in private practice specializing in the law of the sea. She divides her time between London and Honolulu where she is adjunct Professor of ocean policy at the University of Hawaii. Comments on this Soapbox be happily received via e-mail at paverlaan@gn.apc.org.

The 1982 United Nations Convention on the Law of the Sea (LOS Convention) entered into force on November 16, 1994, and now has 123 state parties. The convention establishes a comprehensive, global, legal framework governing not only the sea but also land- and air-based activities affecting the marine environment. Marine research, development, and use are now subject to single or multi-state control everywhere in the ocean.

Living, non-living, traditional, and new resources in the water column, in or on the seabed or subsoil, or in the overlying atmosphere are all covered. Even the "high seas freedoms"—those activities that can be conducted by all states on the (much reduced) high seas—are limited by duties. These include: reserving the high seas for peaceful purposes, conserving living resources, protecting the environment, and having due regard for the interests of states and for activities in the Area (the deep seabed national jurisdiction).

Given the pervasive and comprehensive rights over marine activities assigned by the LOS Convention to states, entrepreneurs should consider the convention in commercial marine resource development and use.

A coastal state's claim out to 12 nautical miles of territorial sea, 200 nautical miles of Exclusive Economic Zone (EEZ) and 200-350 nautical miles of continental shelf may be poorly defined or conflict with claims by other states.

Although the LOS Convention addresses the issue, final resolution is to be protracted; but without it, marine entrepreneurs cannot confidently invest.

It is hoped that state rights, once established, will be towards achieving optimal use of marine resources. A lesson in the opposite is offered by the experience so far under the LOS Convention for marine scientific research: if a coastal state does not fully understand the proposed activity, it risks being either forbidden or regulated so inappropriately that its pursuit becomes uneconomical. A repeat of this unsatisfactory situation for commercial marine resource should be avoided, especially as it is likely to be exacerbated by the increasing use in marine environmental regulation of the precautionary principle, which essentially imposes a difficult burden of showing no environmental detriment from the proposed activity.

The LOS Convention requires states to develop and review, on the best scientific evidence available and in harmony with other states, comprehensive regulations for sustainable development and use of marine resources. The sustainability is derived from and consistent with the unqualified duty of states under the convention to protect and preserve marine environment. Ocean law is also to be reviewed and updated to take account of environmental change and scientific and technological progress. Although not set out as such in this article, this is the practical upshot of a series of requirements on states, which include:

- Using the best scientific evidence available in conserving resources and cooperating in their management in the EEZ on the high seas
- Cooperating in harmonizing approaches to manage resources in enclosed or semi-enclosed seas
- Developing, harmonizing, and enforcing laws and regulations to the marine environment
- Setting scientific criteria to formulate these rules
- Developing and promoting contingency plans for responding to pollution incidents
- Promoting and participating in research on marine pollution and information acquired
- Monitoring risks and effects of marine pollution and in which states permit or engage
- Reporting on the results to competent international organizations.

States need considerable financial and technical resources to execute these responsibilities adequately in the highly complex marine sector. Lack of such resources to regulate imaginatively and appropriately is often invoked by a state as reason for not regulating well, but this generally does not prevent the state from regulating nevertheless. The result is unsatisfactory for all concerned. Both state and entrepreneurs bear the immediate financial and administrative burden of regulation, although entrepreneurs can choose to leave, or not to enter, the arena. The whole community, however, suffers the long-term losses of income, jobs, skills, information, and competitive advantage that may otherwise have been available had state regulation been more soundly based.

In requiring these regulations and their regular revision, the LOS Convention offers a preemptive, win-win approach to resource regulation that may be usefully applied by entrepreneurs. Because the LOS Convention considers that scientific and technological advancements and environmental change should drive marine regulation, marine entrepreneurs are well-placed to offer a progressive, cutting-edge view of the sector. This provides them with an advantageous base from which to participate in designing regulations that encourage optimum development and use of marine resources. Given that regulation of marine activities is now mandatory under the LOS Convention, entrepreneurs could initiate work on those regulations. States are generally receptive to proposals by knowledgeable parties for the administration and generation of revenue from an area of common concern.

Such a proposal can be most persuasive, particularly when it is likely to be the only one on the table and when the state's time and resources to prepare alternatives are almost certainly limited. It also offers marine entrepreneurs early and necessary opportunity to engage the vocal marine constituency in this constructive process.

In conclusion, marine entrepreneurs are encouraged to consider the benefits for marine resource development that may accrue from timely interventions and act accordingly to achieve appropriate state action under the LOS convention. */st/*

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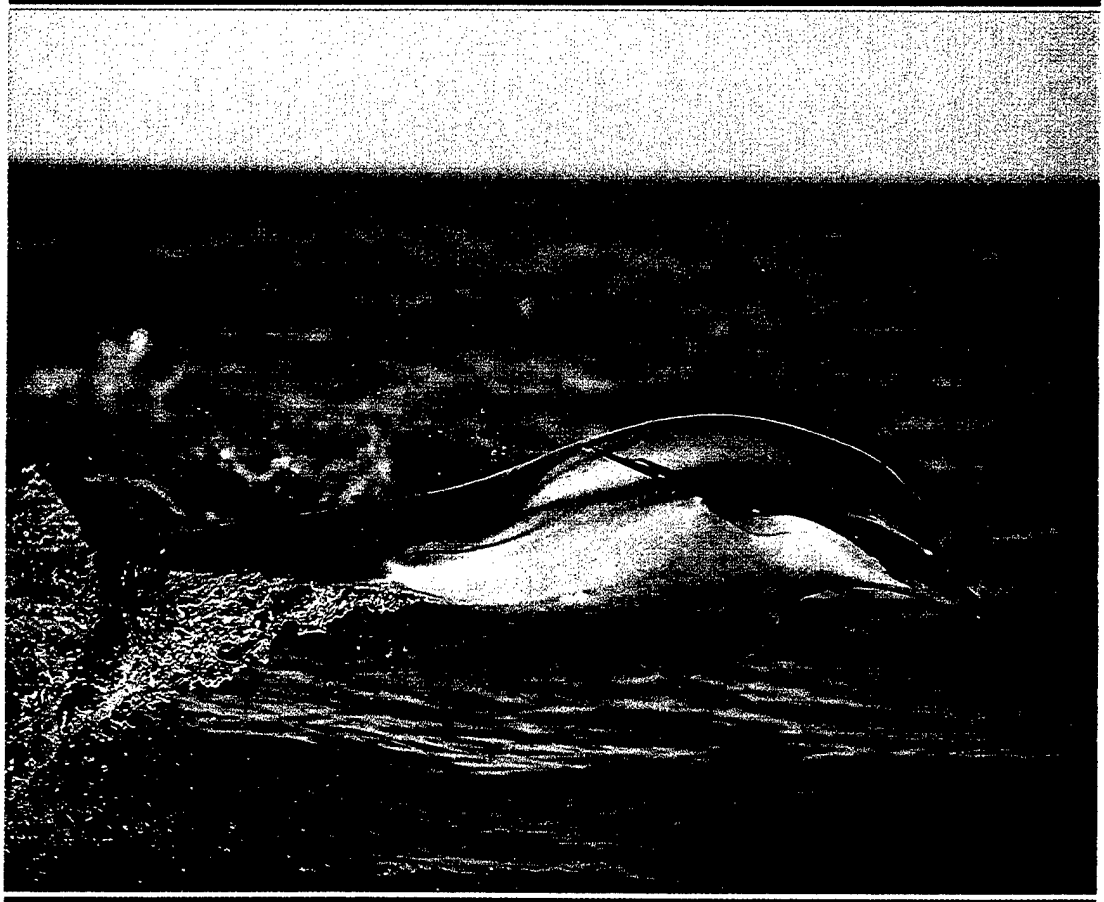

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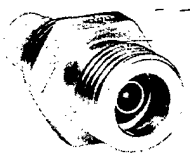

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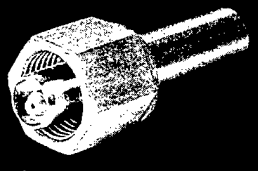

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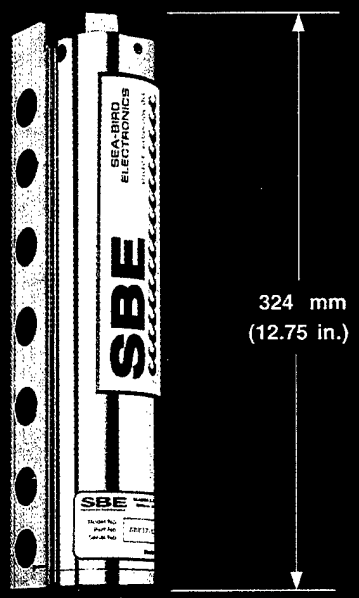

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